

MODEL 1610
SCANNING ELECTRON MICROSCOPE
OPERATORS MANUAL

{ METAL SPRAY'S MODEL IS 1600 }
{ WHICH HAS A ROUND DOOR TO SAMPLE CHAMBER }

PRINCIPAL DIFFERENCES ARE:-

PHYSICAL DIMENSIONS AND
GEOMETRY OF SAMPLE
CHAMBER AND DOOR.

e.g. 1610 HAS A SQUARE DOOR

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Section Six

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Introduction

This book is designed to assist the operator in becoming more familiar with the AMRAY Model 1610/1645 Scanning Electron Microscope. It is divided into six sections. Section One gives a highly detailed description of all of the different systems and controls which make up the SEM. Section Two provides basic operating instructions including initial start-up. Section Three gives instructions for operating the various auxiliary controls found in the upper auxiliary control panel. Section Four describes those accessories and options which may be included with the SEM for use in specialized applications. Routine maintenance and service procedures are covered in Section Five. A list of references is provided in Section Six for those who wish to acquire more information concerning the science of Scanning Electron Microscopy.

While no book or publication can take the place of actual hands-on training, it is our endeavor to provide a publication that can be used along with such training. We would appreciate your comments in order to make this manual better. If you have any such suggestions, please do not hesitate to contact us.

SECTION ONE

SYSTEM DESIGN AND DESCRIPTION

SYSTEM DESIGN and DESCRIPTION

The AMRAY Model 1610/1645 Scanning Electron Microscope (figure 1.1) is a high performance instrument, contained in two modular consoles, the Electron Optics Console (left) and the Electronics and Display Console (right).

Electron Optics Console

The major components of the Electron Optics Console (figure 1.2) are the pre-aligned Electron Optical Column with a fully automatic, turbo-molecular pumped vacuum system and a universal port specimen chamber with a hinged, lift-off specimen stage.

The Electron Optical Column is one of the most important features of the SEM and consists of an externally alignable electron gun, electromagnetic beam alignment section, two condenser lenses, a final "object" lens, stigmator, scanning and static deflection coils, an adjustable final aperture control, a specimen chamber, a hinged lift-off specimen stage, and an electron detector assembly. The entire column is provided with an external electromagnetic shield to eliminate beam distortion and sensitivity to stray fields.

A. Electron Optical Column Components

The components of the Electron Optical Column shown in the cut-away figure 1.3 are described as follows:

1. Electron Gun

The self-biased triode provides a fine, bright source of electrons. The filament may be adjusted with respect to the grid cap. The anode to gun spacing is also externally adjustable for high or low kilovolt (KV) operation. External adjustments allow for mechanically tilting the gun for electron optical alignment.

2. Electromagnetic Beam Alignment

Slight misalignment of the electron beam which may occur during day to day operation is easily corrected with the electromagnetic beam alignment system which greatly simplifies misalignment corrections under all conditions. The controls for this alignment are found on the Electronics and Display Console.

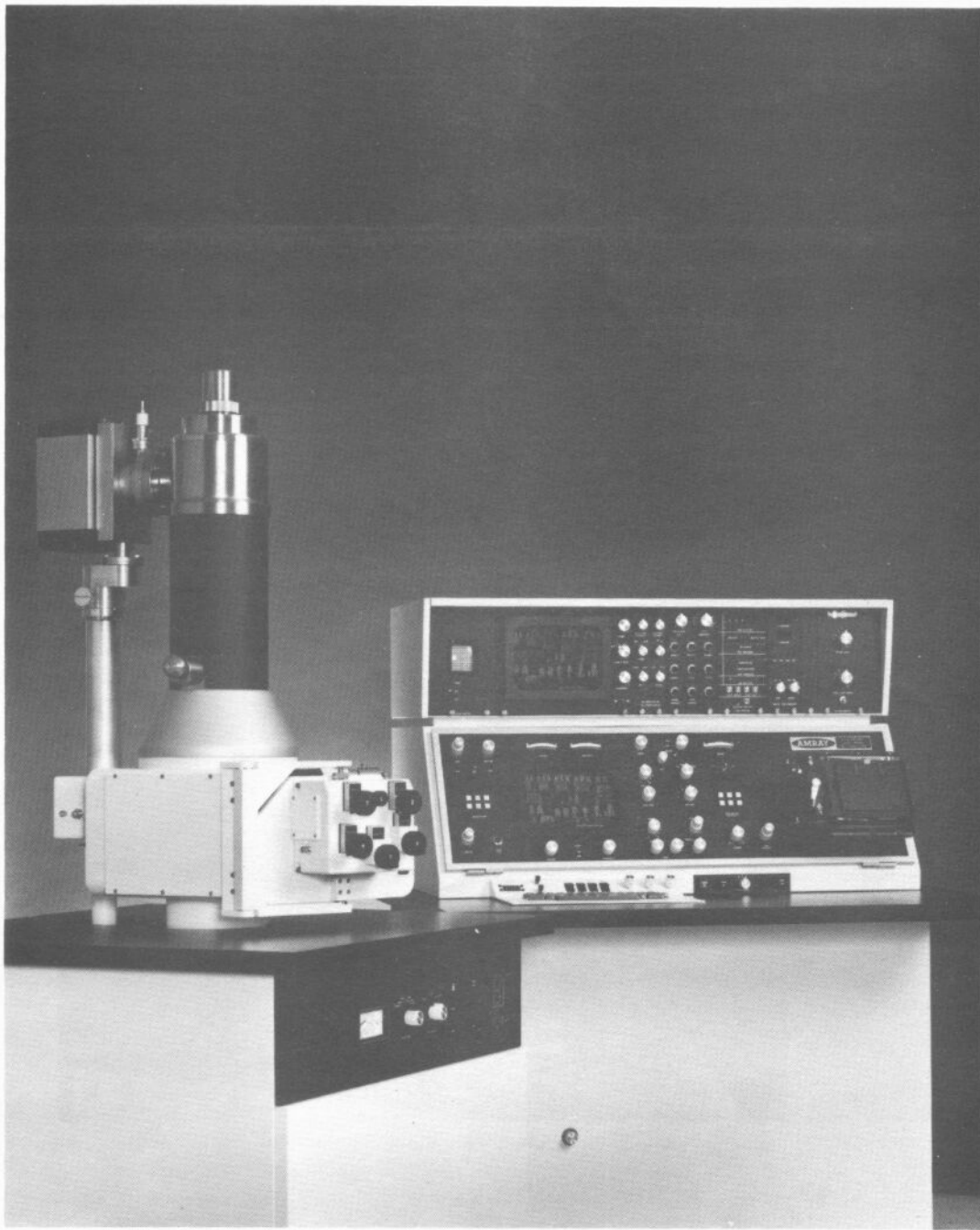


Figure 1.1 MODEL 1610

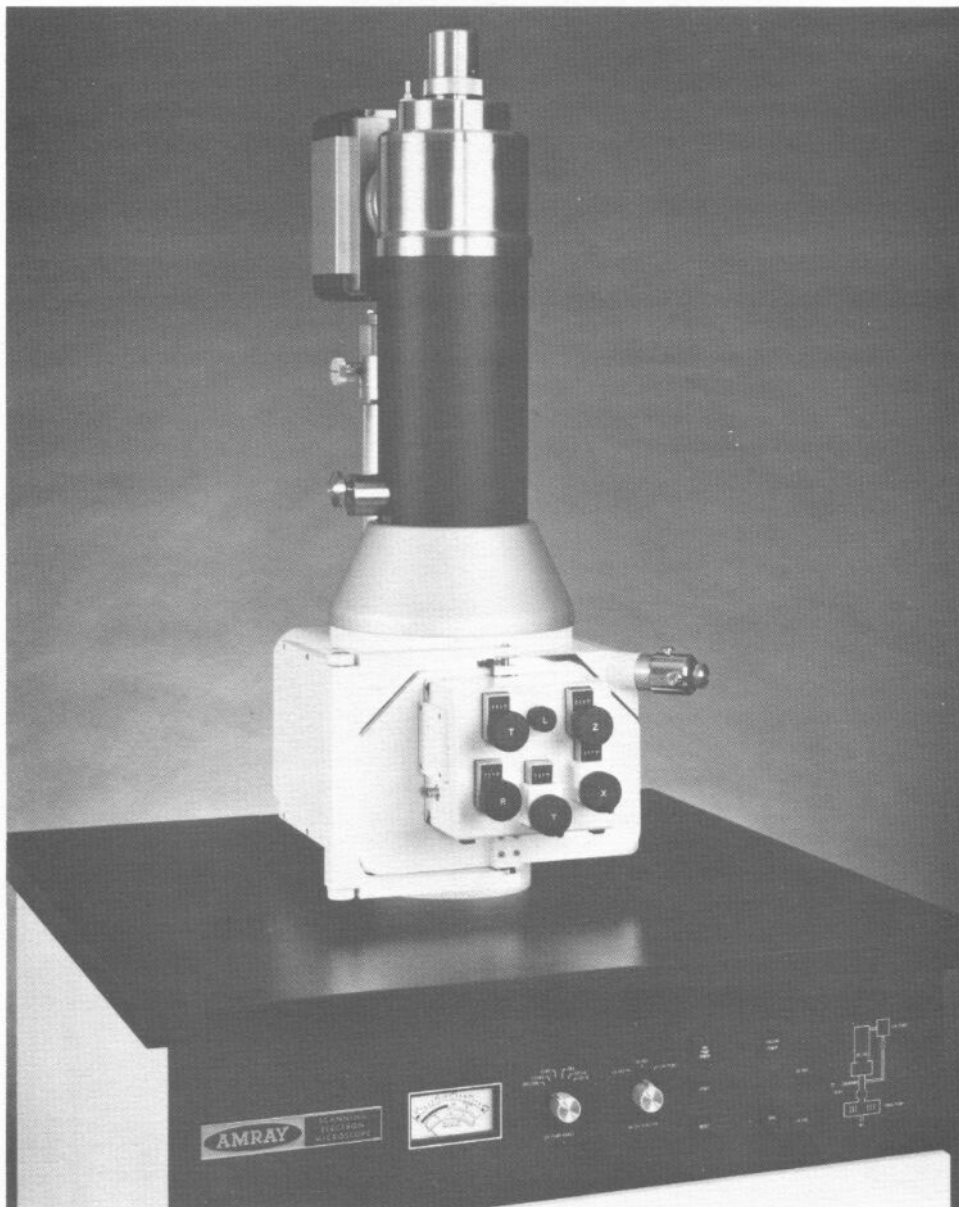


Figure 1.2

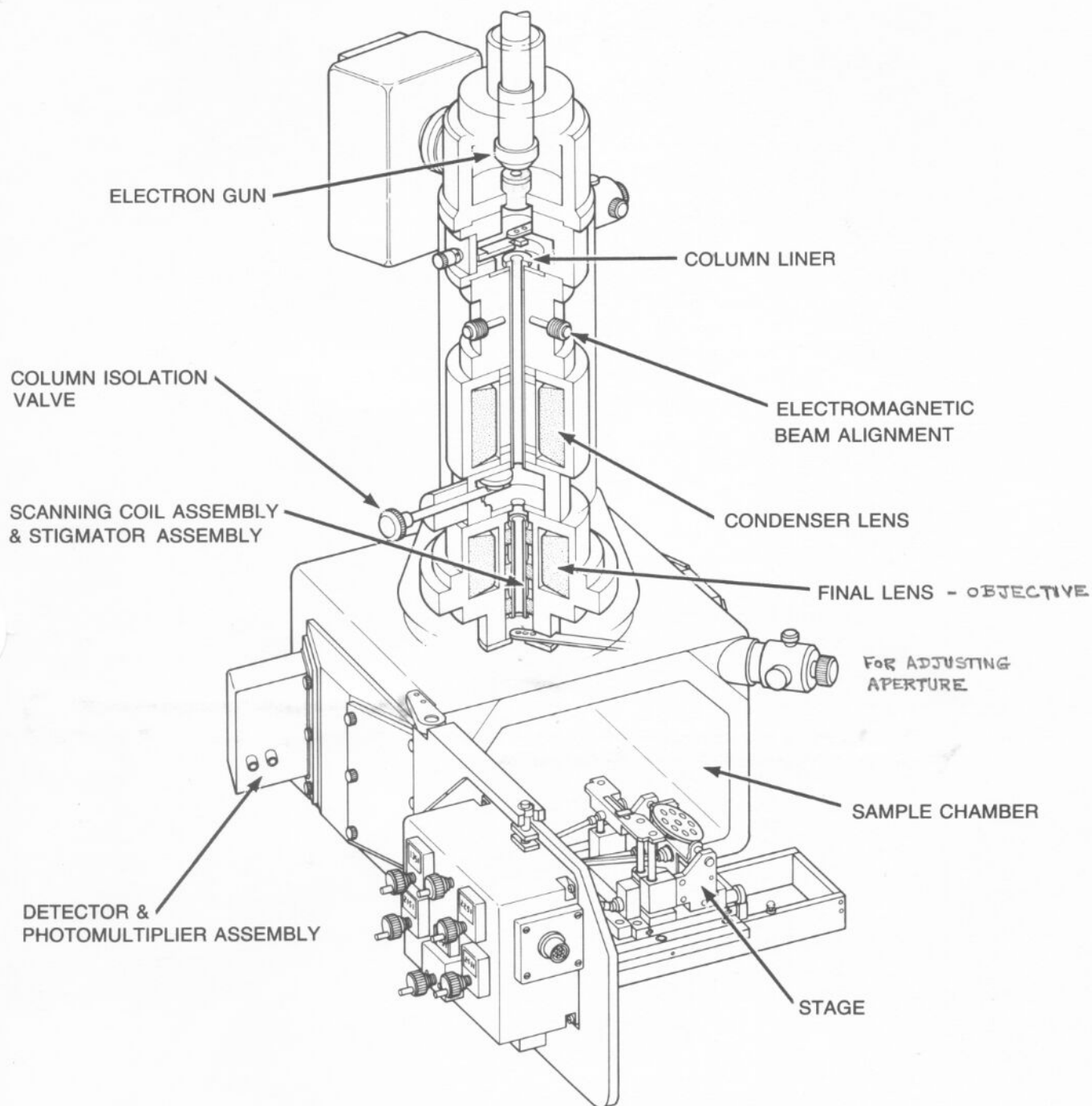


Figure 1.3

SYSTEM DESIGN and DESCRIPTION

Electron Optics Column Components (Cont.)

3. Condenser Lenses

Two symmetrical electromagnetic condenser lenses are contained in a modular cylindrical assembly as a single unit. One field coil excites both condenser lens pole pieces.

4. Column Liner Tube

With the exception of the gun/emission chamber, the entire length of the electron optical column, down to the column isolation valve, is both vacuum sealed and shielded by a non-magnetic alloy column liner tube. Below the isolation valve, a similar liner extends through the scanning coils which are immersed in the final "object" lens.

5. Column Isolation Valve

This valve isolates the electron optical column from the specimen chamber and maintains the column under vacuum during sample exchange.

6. Final "Object" Lens

This spot forming lens is an asymmetrical pin-hole lens with low spherical aberration coefficient and low magnetic leakage. An externally adjustable 3-position aperture assembly (for control of depth of focus and resolution) is located at the principal plane of the lens.

7. Scanning Coil Assembly

This assembly is located in the bore of the final lens and is designed to allow distortion-free X and Y deflections of the beam at the specimen surface. A second control (Scan Shift) allows X and Y displacements of the entire scan raster by application of DC voltages. At higher magnification, changing the field of view, using Scan Shift, will be found to be more convenient than the use of stage controls.

8. Stigmator

The stigmator is located within the scanning coil assembly. It allows for rapid, simple corrections for minor field distortions. The time required for correcting astigmatism is negligible and no change in magnification or incident current occurs. The stigmator may be operated manually or used in the automatic Auto StigTM mode. Controls are located on the Electronics and Display Console.

SYSTEM DESIGN and DESCRIPTION

Electron Optics Column Components (Cont.)

9. Specimen Chamber

The specimen chamber is designed to accommodate various types of stages and a choice of detector and accessory port configurations. The chamber measures eleven inches wide by eleven inches deep by seven inches high.

10. Standard Specimen Stage

The standard manually controlled specimen stage is designed to handle the large specimens typically found in modern semiconductor and materials science applications. The motions provided include X, Y, Z, Rotation and Tilt. The stage is mounted to the hinged/lift-off door of the specimen chamber and may be removed as unit for working on the bench.

11. Electron Detector Assembly

This assembly may be used to collect either low energy secondary electrons or high energy primary backscattered electrons. A positive voltage biased electrode screen (collector screen) attracts the low energy secondary electrons. If the collector screen is negatively voltage biased, the detector will measure high energy primary backscattered electrons only.

The electrons are accelerated by the application of a high positive potential to a scintillator. The light produced is directed to the window of a low noise photo multiplier which provides the basic signal necessary for scanning display image presentation.

12. Automatic Vacuum System

The microprocessor controlled turbo molecular pumped automatic vacuum system is mounted in the console beneath the specimen chamber and is attached directly to the column. The entire system is started, operated, and shut down in a fully automatic mode. Once the vacuum power button is energized, the system cycles to a fully pumped down condition.

This operation is controlled by sensory gauges and solid state relay circuits. Vacuum controls and readouts are located on the vacuum control panel of the Electron Optics Console. The roughing pump is located outside of the vibration isolated console. An electrically operated valve is used to leak the preferable and recommended dry nitrogen gas into the specimen chamber and/or column during specimen insertion or filament exchange.

SYSTEM DESIGN and DESCRIPTION

B. Electronics and Display Console Components

The Electronics and Display Console is functionally divided into a lower Main Control Panel and an upper Auxiliary Control Panel both mounted on a cabinet which houses the power supplies, basic controls and electronics.

The Main Control Panel (figure 1.4) contains the operating controls necessary to interact with the following systems.

- Video Signal Control, Display and Record System.
- Scanning Control System.
- Microprocessor Controlled Digital Mag System.
- Microprocessor Controlled Acceleration Potential System.
- Microprocessor Controlled Electron Optics Control and Compensation System.

The Auxiliary Control Panel (figure 1.4) contains the operating controls for those features which are designed to enhance the main operating control functions and data recording systems of the SEM. These features include:

- Video Signal Monitor.
- Second Signal Display Scope.
- Dual Magnification/Split Screen Imaging.
- Scan and Signal Control Module.
- Microprocessor Controlled Video Signal Processor.
- Systems Monitor.

C. Video Signal Control, Display and Record System (figure 1.5)

1. Contrast Control

The signal from the electron detector is processed by a preamplifier located in a module in the Electron Optics Console cabinet.

Signal amplitude variation is obtained by varying photo-multiplier voltage using the Contrast Control Knob.

2. Gamma Control

After being processed by the preamplifier, the signal is then fed to a signal processing amplifier. At this point, linear or differential gain may be applied by the continuous Gamma Control Knob. This control may not be active if the system contains a Microprocessor Controlled Video Signal Processor.

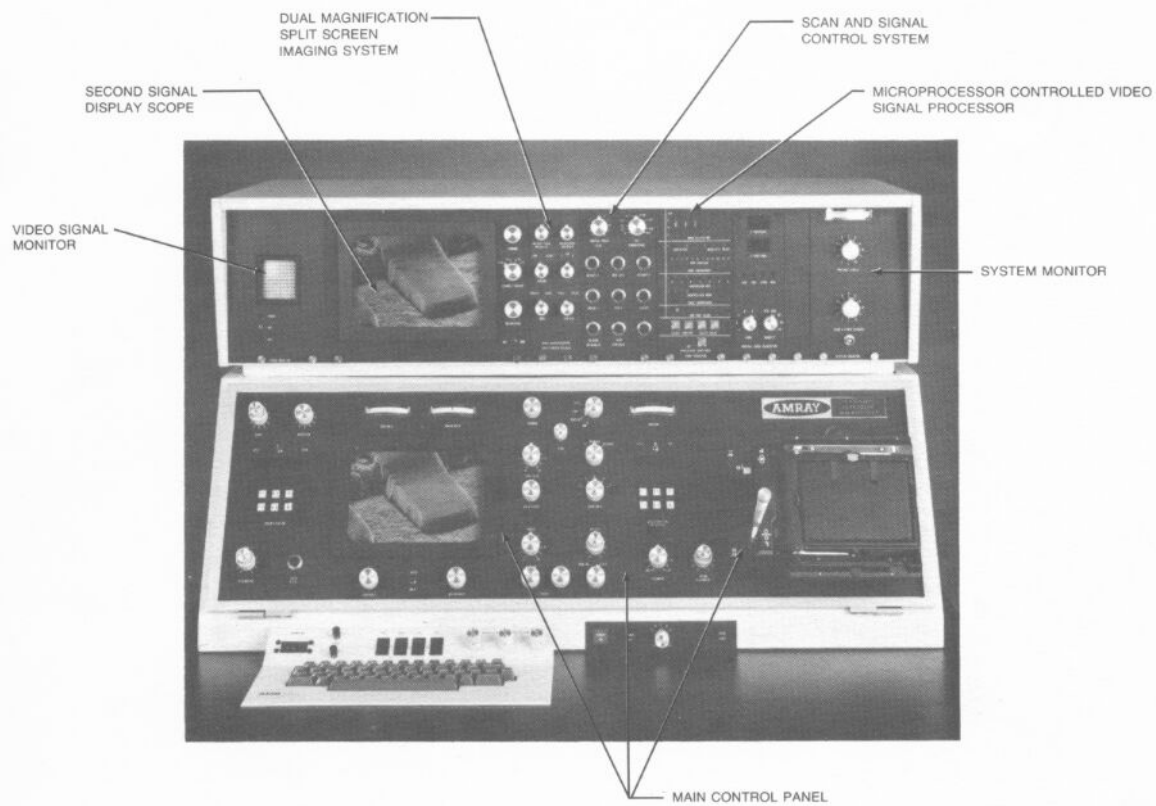


Figure 1.4

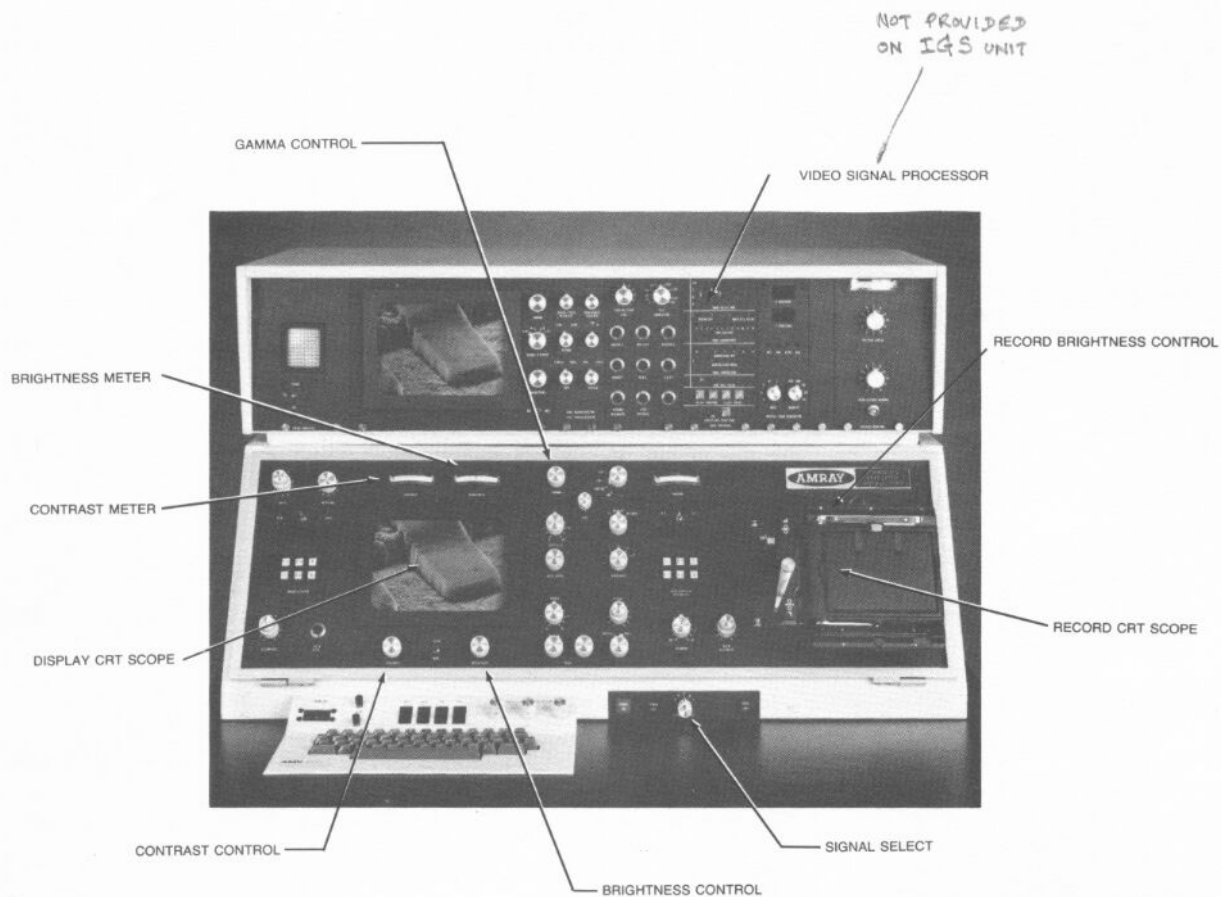


Figure 1.5

SYSTEM DESIGN and DESCRIPTION

Electronics and Display Console Components (Cont.)

3. Video Signal Processor

This allows display of fine detail or the examination of "holes" without losing sensitivity at high signal levels.

NOT PROVIDED
ON IGS UNIT.

4. Display CRT Scope

The image generated from the signal is formed on a 9 inch diagonal cathode-ray tube display scope located on the front of the main control panel.

5. Record CRT Scope

The image can also be displayed on the recording 2500 line CRT scope located in the recess for the standard camera located on the front of the main control panel. Output levels of the signal are continuously displayed on the Waveform Monitor, Brightness, and Contrast meters.

6. Brightness Meter

This meter is used as an integrating device to display the average signal brightness.

7. Brightness Control Knob

This control is used to set the average signal brightness.

8. Contrast Meter

This meter is also used as an integrating device for display of the average picture contrast or, amplitude of the video signal.

9. Signal Select

The signal select knob allows the operator to choose from five different detectors (selection A through E). As commonly wired, A is the secondary electron signal and position B is the backscatter mode from the standard electron detector (with -100 volts on the collector screen). In signal select position C through E, the electron detector is also held at -100 volts on the collector screen and the signal is that from auxiliary detectors, such as X-ray, cathodoluminescence, solid state backscatter, etc.

A and B
only

SYSTEM DESIGN and DESCRIPTION

Electronics and Display Console Components (Cont.)

10. Record Brightness Control

This control is located just above the camera. Once the scope is calibrated for photography, the Record Brightness Control generally need not be adjusted.

D. Scanning Control System (figure 1.6)

The Display Scope, Record Scope and scan coils (located in the electron optical column) are driven with an analog scanning system. This system includes:

1. Raster Mode Switch (TV-DISPLAY-RECORD)

This control is used to select the desired raster scanning mode of operation, i.e. Display mode for viewing on the Display Scope, Record mode for photography, or TV mode when an optional monitor is utilized.

2. Scan Rate Switch (1 THROUGH 6)

In conjunction with the Raster Mode Switch, a Scan Rate Switch allows the operator to select a scanning speed which will produce optimum visual or photographic results. The scanning rate is independently adjusted for either the display or record mode in that the six speed selections in the Display Mode are different from the six speed selections in the Record Mode. A table is provided in Section II, Operating Procedures, which summarizes the actual frame speeds, line scan speeds, etc. associated with the Scan Rate Switch.

3. Scan Mode Select Switch (DM-RASTER-LINE-SPOT)

The Scan Mode switch allows for four distinct modes of operation. In the Raster Mode, the operator would subsequently select the raster speed using the Scan Rate switch and the type of raster using the Raster Mode switch. When the Line Scan Mode is selected, the electron beam generates a line on the specimen. For photographic purposes, the vertical position of the line scan on the display and record scopes may be changed independently of the line scan position on the specimen by using the Brightness Control. The line position on the specimen is changed only by using the Y knob of the Partial Field Offset Control. The height of the signal variations in the Y scan may be changed using the Gain Control of the detector contributing the signal. The Scan Rate Control switch changes the line speeds in this mode. Two lines are shown sequentially; one line with no signal information indicates the line position on the

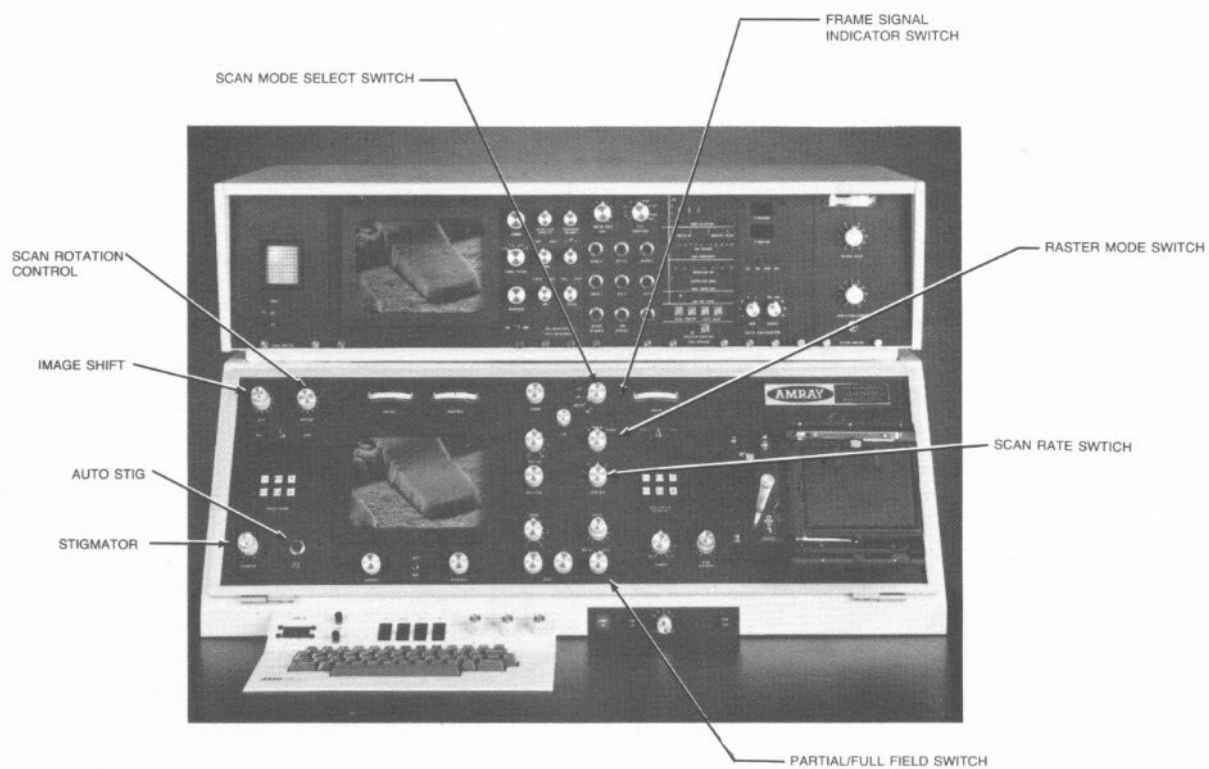


Figure 1.6

SYSTEM DESIGN and DESCRIPTION

Electronics and Display Console Controls (Cont.)

specimen and the second line yields the signal information. In the Spot Mode, the electron beam is positioned at a point on the specimen and is moved from point to point using the Partial Field Offset Control. Even though the beam is a spot on the specimen, the display CRT will show four quadrants, the intersection of the four depicting the "spot" on the sample. The DM Mode (Deflection Modulation or Y Modulation) generates a raster on the specimen surface and the time varying signal is used to modulate the Y axis of the line on the Display and Record Scopes.

4. Partial/Full Field Switch

The selection of Partial Field, with the Partial/Full Field Switch, results in a reduced area scan on both the sample and CRT. The location of the scan is selected by using the Partial Field Offset (dual) Control. If the Raster Mode Switch is turned to Record, the scan generator will continue to produce a partial raster and the Frame Signal Indicator light will turn on at the end of the partial raster.

5. Frame Signal Indicator Switch

When this red light/button is depressed, a single frame scan will be initiated. The Record Scope is simultaneously turned on. After completing a single frame, the the record raster stops and the red indicator will light. Multiple exposures may be accomplished by utilizing the Record Integrate Mode button located on the Auxiliary Control Panel or by repeatedly energizing the Frame Signal Indicator Switch.

6. Stigmator

The Stigmator Dual Rotary Control is used to correct slight ellipticities of the focused beam produced by contamination and/or distortion of the lens field. The stigmator control can be used as a standard manual X and Y stigmator or in a semi-automatic mode (see 7 below).

7. Auto Stig^(TM)

This feature allows the stigmation control to become semi-automatic. When the Auto Stig button is energized, the entire Display Scope is utilized as a map and illustrates all combinations of the X and Y stigmator strengths as well as final lens focus controls. The operator need only set the movable cross-hair at a point he selects for stigmation and resume the AUTO STIG^(TM) switch.

SYSTEM DESIGN AND DESCRIPTION

Electronics and Display Console Controls (Cont.)

8. Image Shift Control

The Image Shift dual rotary control allows for static lateral displacement of the scan raster in either of two orthogonal directions. This allows the operator to align fields of interest at high magnifications, where the specimen stage controls may be too coarse for satisfactory control.

9. Scan Rotation Control

The Scan Rotation Control electrically rotates the scan raster or scan line to any orientation from 0° through 360°. It is also microprocessor digitally controlled and the rotation angle is illustrated on the KV/Scan Rotation LED readout display.

E. Microprocessor Controlled Digital Magnification System (figure. 1.7)

The desired magnification is regulated by a compact array of controls similar to, but separate from those used for acceleration potential. These controls are described as follows:

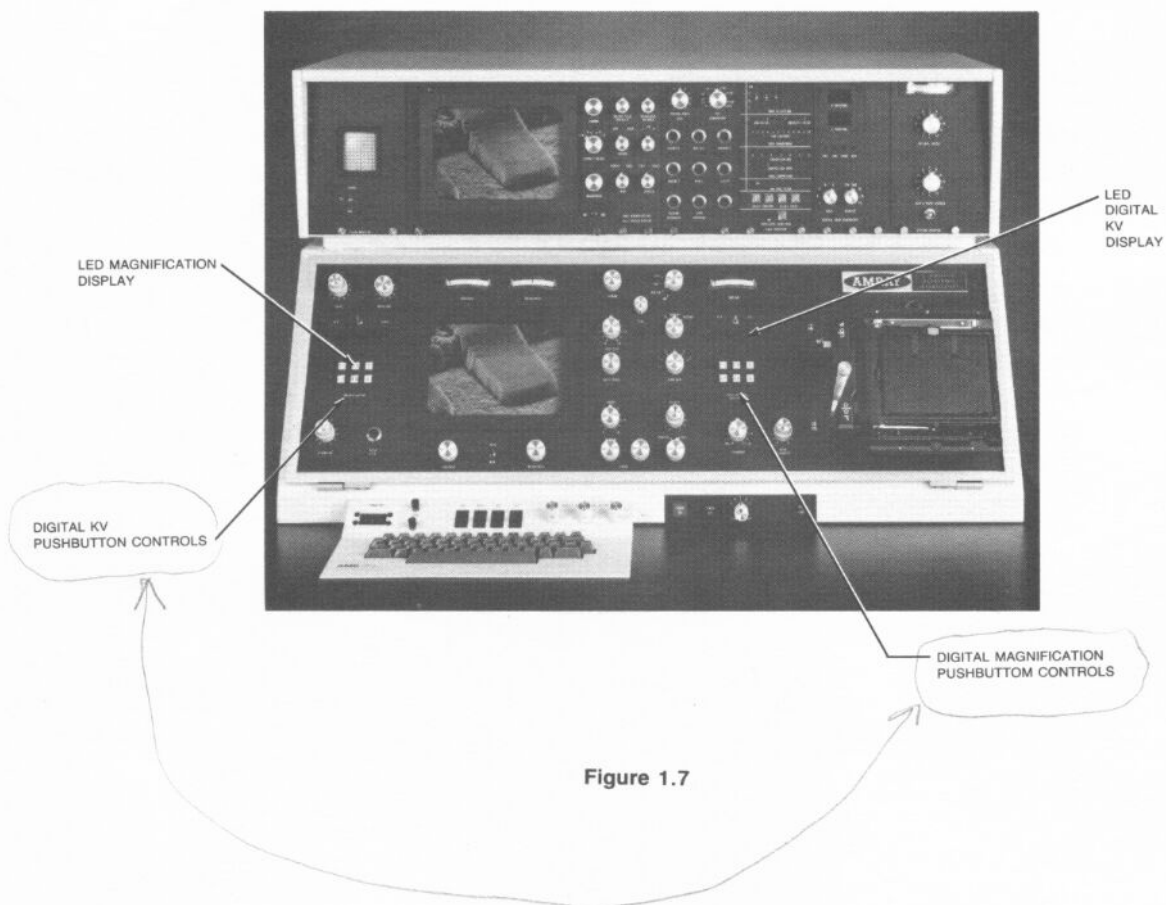
1. Digital Magnification Pushbutton Controls

These six pushbuttons mounted on the left side of the front panel send commands directly to the microprocessor.

For convenience in focusing or stage positioning, the left pair of pushbuttons permit instant 10X magnification increase or decrease. The middle-pair of pushbuttons controls a power zoom that provides smooth and rapid increase or decrease in image magnification continuously throughout the entire 25,000:1 range at a constant logarithmic rate.

The right pair of pushbuttons (low speed zoom) control image magnification precisely to a desired value, stopping at any one of 900 steps per decade.

The microprocessor not only follows the selection of the pushbutton array, but also senses the final lens focus, KV, and scan coil deflection and calculates and displays a precise current magnification corrected for continuous changes in working distance and electron beam energy.



SYSTEM DESIGN AND DESCRIPTION

Electronics and Display Console Controls (Cont.)

2. LED Display

Incorporated within the system is a direct, digital readout of the magnification and/or working distance exhibited on a three-digit LED Display, as well as being printed in recorded micrographs.

F. Microprocessor Controlled Acceleration Potential (Fig. 1.7)

The front panel of the AMRAY 1610 SEM contains controls interacting with the dedicated microprocessor system for selecting acceleration potential (KV). The controls are:

1. Digital KV Pushbutton Controls.

The desired KV is selected by the operator using a compact array of six Digital Pushbutton Controls, which send commands directly to the microprocessor.

The commands received by the computer to set the desired operating KV are then utilized to control the electron optical components of the SEM in order to establish the proper operating conditions. The microprocessor smoothly changes the excitations of both the condenser lenses and the final lens in order to maintain the current focal lengths as the KV is changed. The deflection of the scanning system is also compensated to maintain accurate magnification control.

2. LED Display

A three-digit LED Display is incorporated within the system to accurately display the selected KV, as well as to forward it for recording on micrographs.

G. Electron Optics Control and Compensation (figure 1.8)

The diameter of the electron beam which scans the surface of the specimen is commonly referred to as the spot size. The Electron Optics Control System utilizes the upper two condenser lenses in the Optical Column to produce the spot size required. The system also utilizes the final "object" lens to focus the beam onto the surface of the specimen. The controls for this system are:

1. Spot Size Switch (Condenser Lenses)

This control is an eleven step switch located on the front panel next to the display scope. Higher numbers on this switch produce a smaller beam with reduced incident beam current.

= higher resolution

EDS ~~is~~ larger beam to enhance the intensity (count rate) of x-ray
High mag. " spot size no. 小.
" " " " 大.

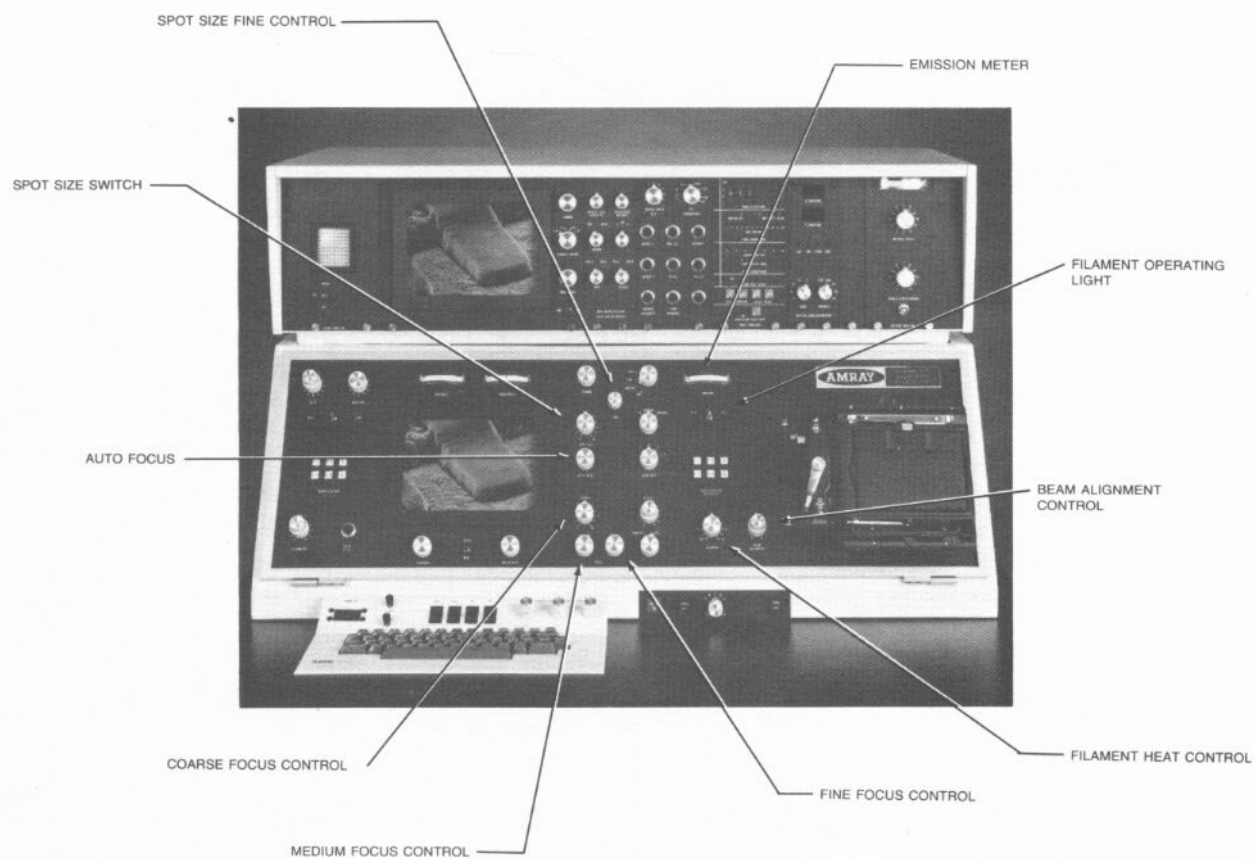


Figure 1.8

SYSTEM DESIGN AND DESCRIPTION

Electronics and Display Console Controls (Cont.)

2. Spot Size Fine Control

A continuous fine control is located on the front panel opposite the Spot Size Switch and used in conjunction with it. Each turn of the control (10 turn potentiometer) is equivalent to one unit change on the spot size switch.

By turning the Spot Size Switch and Spot Size Fine Control Clockwise, the lens current in the upper two condenser lenses is increased. As the current in the upper two condenser lenses is increased, the focal lengths are decreased and the incident spot size on the specimen is reduced. Therefore, the higher the number on the Spot Size Switch, the smaller the beam diameter.

3. Coarse Focus Control ("Object" lens)

This control is an 11-step switch located on the front panel of the main console, to the right of the Display Scope.

4. Medium Focus Control

A continuous focus control located below the coarse focus control.

5. Fine Focus Control

A fine continuous focus control located to the right of the Medium Focus Control.

The controls 3 through 5 used in conjunction permit the Final "Object" lens to focus the beam onto the specimen.

6. Auto Focus Control

This control, located above the focusing controls, provides for maintaining depth of focus on a tilted specimen. The final lens is programmed to change focus in a continuous, systematic fashion along the tilt plane of the specimen. When not in use, this control must be turned completely counterclockwise.

7. Filament Heat Control

This continuous control regulates the current flowing in the electron gun filament. Filament heating is accomplished by first turning the control counter-clockwise against a reset stop and by then turning it clockwise until saturation is reached (see Section II). p 34, p 35

SYSTEM DESIGN AND DESCRIPTION

Electronic and Display Console (Cont.)

8. Emission Meter

This meter indicates the total electron gun emission current developed.

9. Filament Operating Light

This indicator light will turn on whenever the filament has failed or the filament heat is not powered.

10. Beam Alignment Control - CONCENTRIC POTS (EXTREME LOWER RIGHT).

The Dual Beam Alignment controls the strength of electromagnetic field coils situated just below the emission chamber. This control is used in conjunction with the three mechanical gun tilt controls at the emission chamber.

(Section III). [See p68] - (To maximise signal on Video Monitor Scope.)

H. Auxiliary Control Panel (figure 1.9)

This section of the Electronics and Display Console contains features and controls which support and enhance the systems contained in the Main Control Panel. figure 1.9 displays those listed below.

1. Video Signal Monitor Scope

This scope displays the real time video signal and acts as an aid to the operator in setting contrast on most specimens. A grey scale can be set up by selecting a signal excursion with limits between the white and black extremes. Screw-slot controls for focus, astigmatism and intensity are located below this monitor scope.

2. Second Signal Display Scope

This allows the operator the capability of viewing signals from two different detectors simultaneously. It may also be utilized when operating in the Dual Magnification mode.

3. Signal Two Select Switch

The Signal Two Switch is used to select the standard secondary detector signal or any one of three other detector signals for display on the Second Display Scope.

4. Brightness Control

This control regulates the brightness for the Second Signal Display scope.

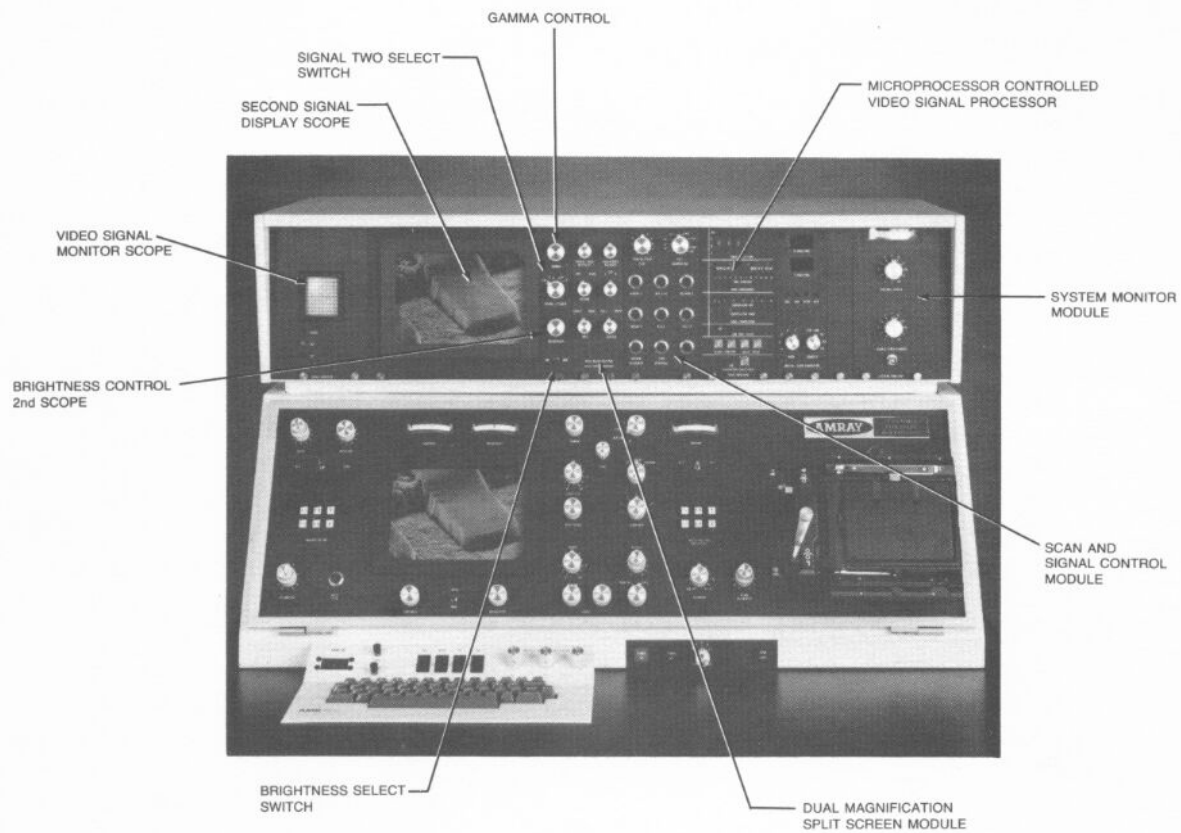


Figure 1.9

SYSTEM DESIGN AND DESCRIPTION

Electronics and Display Console Controls (Cont.)

5. Brightness Select Switch

This switch, when placed in the BRI position, allows the brightness of the Second Signal Display scope to follow the brightness changes of the primary display scope. In BR2, the brightness control only changes brightness on the Second Display Scope.

6. Gamma Control

This control duplicates the function of the Gamma Control on the Main Control Panel (see A-2) for auxiliary signals on the Second Display Scope. This function is rarely present in operating SEMs.

7. Dual Magnification/Split Screen Module

This module consists of six rotary switches which allow the operator to simultaneously view the same specimen area at two different magnifications on the same display scope or on two Display Scopes. It also allows simultaneous imaging of two different signals in a split screen mode. Each mode is shown on one-half of the scope. (Refer to Section III for Special Instructions).

8. Scan and Signal Control Module

The module provides an additional twelve operator selected control functions, which may be utilized to extend, or to complement the versatility of standard or non-standard electron beam scanning, image viewing and recording modes. The functions are selected by the use of pushbutton red indicator lights or by rotary switches which control the magnitude of the desired function. (Refer to Section III for Special Instructions).

NOT PROVIDED
ON IGS UNIT

9. Microprocessor Controlled Video Signal Processor

This module allows for microprocessor control of signal mixing (four detector inputs), filtering, gamma, first derivative, second derivative and automatic compensation of selected features with scan rate. (Refer to Section III for Special Instructions).

NOT PROVIDED
ON IGS UNIT

10. Systems Monitor Module

This module provides for a diagnostic analysis of power supply voltages and waveforms via meter readout and CRT test points. The diagnostic function helps to insure that the key electronic functions of the SEM are within the specifications required for proper performance. (Refer to Section III for Special Instructions)

SYSTEM DESIGN AND DESCRIPTION

Electronics and Display Console Controls (Cont.)

11. Alphanumeric Digital Printout

Automatic alphanumeric data annotation of the Display Scope, TV Monitor and the Record Scope is accomplished by a microprocessor system. A single line of alphanumeric data appears at the bottom edge of the scope and is printed on the recorded micrograph. The printed information includes KV, magnification, micron marker, and picture number. Both the magnification and the micron marker are compensated for acceleration potential and continuous changes in working distance. This module is not present when the Keyboard Data Entry System is present.

SECTION TWO

OPERATING PROCEDURES

V₂ is always closed except when starting

OPERATING PROCEDURES

A. General Precautions

The following precautions should be adhered to before and during SEM operation.

1. An individual who has only limited experience in the use of the SEM should become familiar with the controls and system design as detailed in Section One of this book.
2. Never disconnect electrical leads when power is applied to the SEM.
3. Do not open the Column Isolation Valve (figure 2.1) if the specimen chamber is vented and the electron gun area is under vacuum. *(V₁)*
4. Always keep the Column Isolation Valve closed until the "Hi Vac" and "Lo Vac" lights turn green.
5. Do not attempt to remove the final aperture holder while the specimen chamber is under vacuum.
6. Do not leave the Ion Pump Start button in the ON position (light on), except during supervised Ion Pump start-up. In this mode, the ion pump power supply is not current-limit protected in case of vacuum failure.
7. Always close the Column Isolation Valve (figure 2.1) before turning off Console Power. This practice helps to protect the display scope (CRT) from burn spots. *(V₁)*

B. Obtaining a Column Vacuum (with a fully vented column and gun)

Standard SEMs without a Vac-Ion Pumped Emission Chamber (for optional Vac-Ion pumped systems (see page 29)).

1. Close the Column Isolation Valve (figure 2.1).
2. Ensure that the specimen stage door O-ring is clean and the door is sealed to the specimen chamber.
3. Push Vacuum Power button On (light on).

NOTE: The turbomolecular and mechanical pumps are now beginning their pump-down cycle. If at this point, a vacuum alarm sounds, press the Vacuum Power button off and check to see that the column isolation valve is completely closed before pushing the Vacuum Power On again.

4. Turn Meter Function knob to the Lo-Vac setting. Monitor pressure on the lower scale of the combination vacuum/current meter.

SEE NEXT
PAGE 29

NOTE: 18 DEC. 2008. SERVICE BY JAMES FOTINOPOULOS.

HE STATED THAT V1 IS KNOWN AS V1, AND THAT V3 IS COLUMN ISOLATION VALVE. HE WAS ADAMANT ABOUT THIS ALTHOUGH IT SEEMS ILLOGICAL.

V1 COULD BE CALLED THE "MAIN ISOLATION VALVE."

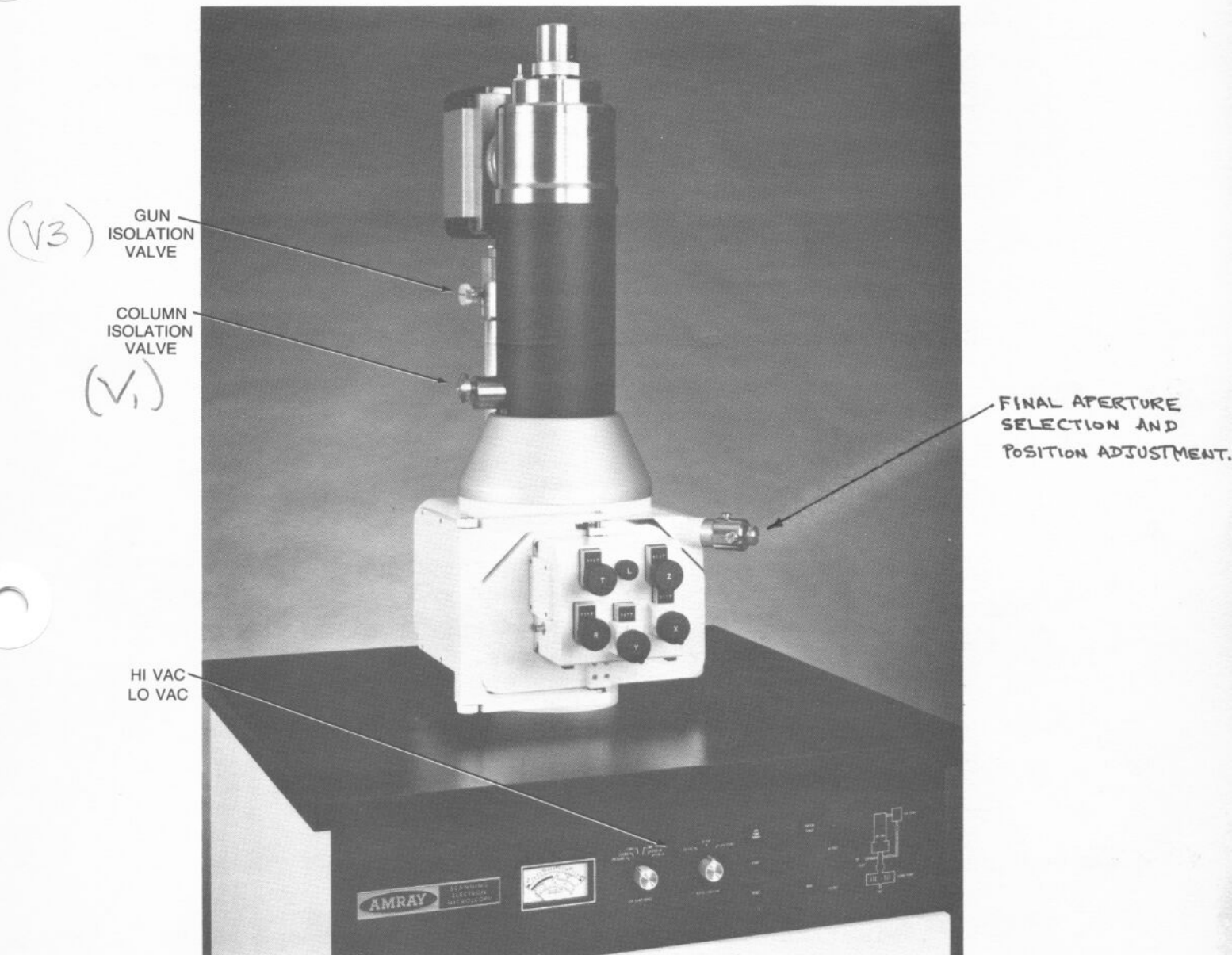


Figure 2.1

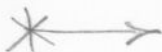
VENT VALVE (SOLENOID TYPE) IS V2 - supplies dry N₂ for purge.

OPERATING PROCEDURES

Obtaining a Column Vacuum (Cont.)

5. As the needle moves to the right, an automatic emission chamber roughing valve, which isolates the turbo pump from the electron gun, will open. When the needle has moved all the way to the right, the Meter Function knob can be turned to the Hi-Vac setting as an interim check. System is now ready for use.

YES



SEMs With Optional Vac-Ion Pumped Gun Emission Chamber

1. Ion Pump power should be off. (VI)
- VI CLOSED 2. Close the column ~~Isolation Valve~~.
- ✓3 OPENED 3. Open the Gun Isolation Valve (butterfly valve) located just behind and beneath the Ion Pump (figure 2.1).
4. Follow steps 3 through 5 in the previous instructions for Non-Ion Pumped Emission Chamber (Note: Automatic emission chamber roughing valve not present).

This is not visible unless Ion Pump Power is switched on

VI OPENED

5. After the vacuum system has sequenced normally and foreline pressure is in the 1 to 20u range and high vacuum gauge shows well into the green (10^{-5} torr), allow the system to pump for another 5-15 minutes. Opening the column isolation valve helps to pump out the column liner.

You cannot see this unless Ion Pump Power is "ON"

VI & V3 OPEN

6. Only after the emission chamber and the column have been pumped sufficiently to reach a good vacuum low (10^{-5} torr) is ion-pumping initiated. Initial ion-pumping will involve an interrupted turn on - turn off sequence as follows:
- a. Column isolation valve and gun isolation valve open. (Fig. 2.1)
- b. Select 200 ma scale on ion pump current and vacuum meter readout selection control.
- c. Make sure ion pump high voltage cable is connected and well seated.
- d. Energize start button on ion pump control panel and then energize ion pump power.
- e. If reset switch light indicates, push reset switch.
- f. Indication of ion pump operation is noted as the meter reading of ion pump current rises instantly from a high of 50 to 150 ma and then begins to move left slowly toward lower current levels of 50 to 100 ma.

Query this. You need Ion Pump Power On to get Green Hi Vac LED on.

Obtaining a Column Vacuum (with a fully vented column and gun)

Standard SEMs without a Vac-Ion Pumped Emission Chamber (for optional Vac-Ion pumped systems (see page 29)).

1. Close the Column Isolation Valve (figure 2.1).
2. Ensure that the specimen stage door O-ring is clean and the door is sealed to the specimen chamber.
3. Push Vacuum Power button On (light on).

NOTE: The turbomolecular and mechanical pumps are now beginning their pump-down cycle. If at this point, a vacuum alarm sounds, press the Vacuum Power button off and check to see that the column isolation valve is completely closed before pushing the Vacuum Power On again.

4. Turn Meter Function knob to the Lo-Vac setting. Monitor pressure on the lower scale of the combination vacuum/current meter.
-

OPERATING PROCEDURES

Obtaining a Column Vacuum (Cont.)

- g. Allow ion pump to operate this way for only about 1-2 minutes or until meter reading shows current does not continue to improve.
- h. At this point, shut off ion pump power and wait 1-3 minutes. This procedure is followed in order to avoid over-heating of ion pump module, which yields excessive degassing in ion pump, thus greatly decreasing pumping speed.
- i. After cooling for a few minutes, again re-energize ion-pump power. Current reading may momentarily somewhat exceed former lowest current level attained, but should soon attain levels below former readings.
- j. Repeat this sequential on-off procedure until a current level of 20 to 35 ma is attained. This may require several on-off sequences.
- k. At this point, the ion pump may be left on, but pumping of the gun chamber is accomplished by a combination of ion and turbo pumping, since both the V1 valve and the Gun Isolation valve are open. (V3). V1 & V3 OPEN
- l. Allow combination pumping to continue until current reading is 10 to 15 ma on the 20 ma scale. The back of the ion pump may be quite warm, but should not be too hot to touch!
- m. At this ^{stage} time, observe the current reading as the gun isolation valve just behind and below the ion pump is opened and closed. V3 OPENED AND CLOSED
- n. At a current reading of 8-15ma, it should be possible to keep the Gun Isolation valve closed and still observe continuous improvement in pumping (i.e. lower pump current levels). The ion pump current will continue to decrease as the vacuum improves. ← V3 CLOSED
- o. At this point, the Start switch may be depressed (light out), placing the system in current-overload protect mode. WHICH IS SAFE
- p. After pumping 15 to 20 minutes, vacuum levels in the low 10^{-6} torr range and perhaps 10^{-7} will be attained (switch to pressure on meter range selection control).
- q. Ultimate vacuums of 2×10^{-7} to 4×10^{-7} should be attained within a few hours on new systems and more rapidly on systems which have been in use for some time.

OPERATING PROCEDURES

Obtaining a Column Vacuum (Cont.)

Warning: If the ion pump continues to feel warm after 10-20 hours, there is probably a vacuum leak present. In normal operation, the ion pump should operate at room temperature and actually feel "cool" to the touch.

The current should be low - $< 100 \mu A$

Overnight or Extended Non-Use Condition

1. The ion pump should be allowed to pump the emission chamber and column liner continuously at night or whenever the microscope is not in use.
2. It is also recommended that the turbo pumping station also operate continuously at night or whenever the microscope is not in use for significant periods of time.
3. Important: The column isolation valve must remain closed during each night, or standby operation, or whenever the specimen chamber is not being pumped. If this is not done, the ion pump will try to pump out the specimen chamber through the column liner, which will result in degradation of gun chamber vacuum and dangerous over-heating of the ion pump.

** Close V1 whenever leave microscope.*

Operating Vacuum when Electron Source is in Use

It is normal for ion pump vacuum levels to rise from 2×10^{-7} to 6×10^{-7} torr after source has been in operation for 1 to 10 hours. However, over a period of time, the pressure will improve as the ceramic support, chamber walls, Wehnelt cap, etc. become degassed.

When the proper vacuum pressures are reached, the Lo-Vac and Hi-Vac green indicator lights (figure 2.1) will go on. The system is now ready for operation.

C. Turning the SEM on from Standby Condition (Gun is pumped)

The Standby condition is normally that condition from which the SEM operator would start operation on a daily basis. In this position, the following conditions exist:

- a. Vacuum power is ON.
- b. System is pumped down. *VAC PRESSURE $< 1 \times 10^{-6}$*
- c. Column isolation valve is closed.
- d. Gun isolation valve is closed. $\ominus$
- e. Main power to the Electronics and Display Console is OFF.

*V1 IS CLOSED
V3 IS CLOSED*

OPERATING PROCEDURES

Turning the SEM On (Cont.)

Operating the Vacuum System

1. Set Meter Function knob to the Hi-Vac setting.
2. Pressure on meter should be 10^{-5} to 10^{-6} torr range. ($< 1 \times 10^{-6}$)
Return to Lo Vac position.
3. If a tungsten filament is used, follow steps under Upper Auxiliary Control Panel below.
4. If a LaB₆ filament is used, set the meter function knob to the Ion Pump setting.
5. Turn Ion Pump ^{Range} knob to Pressure setting.
6. Pressure on the scale of the meter should read between 2×10^{-7} and 4×10^{-7} torr.

Operating the Control Console

Upper Auxiliary Control Panel

1. All control knobs in the Upper Auxiliary Control Panel should be full counterclockwise or to the left.
2. All push buttons in the upper control panel should be off.

Lower Main Control Panel

1. Turn filament knob to full counterclockwise position (heat off).
2. Turn both inner and outer, image shift, stigmator, offset, etc. knobs to a 12 o'clock setting.
3. Turn the Signal Select knob to setting A and refer to the Video Signal Processor operation.
4. Turn both inner and outer Beam Alignment knobs to a 12 o'clock setting.
5. Turn Auto Focus to a full counterclockwise setting (off).
6. Turn the Scan Mode Selection Switch to the Raster setting.
7. Turn Raster Mode Switch to the Display setting.
8. The SEM is now ready for specimen insertion and obtaining the electron beam.

OPERATING PROCEDURES

D. Inserting and Exchanging the Specimen

The Specimen Stage of the AMRAY 1610/1645 Turbo is designed to accept a wide variety of specimen sizes. Most applications will utilize a direct stub type specimen holder, which is inserted directly into the stage receptacle. Wafer specimens use wafer holders with/without an offset mounting. Optimum sample positions are most easily achieved with a specimen mount of 2" or smaller. This allows the sample to be placed at approximately the tilt axis of the stage yoke and helps minimize large field of view changes when significant tilt changes are made.

The following procedure covers the insertion or exchange of specimens. At the start of the procedure, the column will be under high vacuum and the electron beam may or may not be on.

1. Close the Column Isolation Valve by pressing in the leaf spring catch and sliding the valve inward. In order to insure a final seal of the valve, hold the column with the palm of one hand and firmly press the valve inward with the other hand.

Note: The red indicator light located on the Vacuum System Panel, marked Col.Isol., should start blinking.

2. Press the Vent button (light on). *(This opens solenoid Valve V2)*

Note: If the venting cycle does not initiate check the Column Isolation valve for a firm seat.

AMRAY recommends venting to a pre-purified grade of dry nitrogen gas to obtain faster chamber roughing, less contamination and long detector and filament life.

DRY NITROGEN
USED FOR PURGE
DURING VENTING

Argon, or even Dry Air

O.K. for IGS.

type of work.

3. When the column reaches atmospheric pressure, lower the specimen receptacle by turning the Z Axis Control knob *anti-*clockwise and disengage the stage lock knob by turning counterclockwise.
4. Withdraw the hinged specimen stage slowly, to avoid hitting the sides of the specimen chamber.
5. Insert or exchange the specimen stub mount, maintaining the sample top near the tilt axis. Tightening the stub clamping set-screw may be required.
6. Slowly close the hinged specimen stage. There will be a slight resistance when the stage door meets the

OPERATING PROCEDURES

Inserting or Exchanging the Specimen (Cont.)

chamber. This is normal. Hold the stage door firmly against the chamber and, at the same time, press the Vent button (light off). The starting vacuum will pull the specimen stage door closed.

7. When the Hi-Vac and Lo-Vac green indicator lights located on the Vacuum System Panel turn on and the red Col. Isol. light starts blinking, the Column Isolation valve can then be opened. *< Check Vac Pressure $< 1 \times 10^{-6}$*

E. Obtaining the Electron Beam

The following procedure for acquiring and optimizing the electron beam requires that the operator perform these preliminary steps.

- a. Turn the Beam Alignment control to a 12 o'clock position (both inner and outer knobs).
- b. Turn the filament control fully counterclockwise (unless a LaB_6 source is present and energized).
- c. Set the pushbutton Digital Magnification Control to the lowest setting.
- d. Check to ensure that the Hi-Vac and Lo-Vac indicator lights are green. *Check VAC Pressure $< 1 \times 10^{-6}$*
- e. Press the Power pushbutton so that it illuminates, indicating that there is power to the console.
- f. Open the Column Isolation Valve.

After the preceding steps have been accomplished, proceed with the following steps (1-10) in order to successfully obtain an electron beam.

1. Select the desired KV (acceleration potential).

Note: There is an array of six pushbuttons which control KV selection. The three upper pushbuttons control KV setting increase, and the three lower pushbuttons control KV setting decreases.

The left pushbuttons (marked with an arrow and a ten) select acceleration potential in steps of 10KV for rapid changes in operating conditions.

The pushbuttons in the middle (marked with 2 arrows) change the acceleration potential in 1KV steps over the full range

OPERATING PROCEDURES

Obtaining the Electron Beam (Cont.)

of the high voltage power supply. The right side push-buttons (marked with a single arrow) will change the KV in steps of 100 volts in the range of 0 to 10 KV. A three digit LED display is incorporated.

2. Select Low Magnification (approx. 20X)

Note: The magnification controls include a compact array of six pushbuttons similar to, but separate from, the pushbutton array used for KV selection.

The upper three pushbuttons are used to increase magnification and the lower three pushbuttons to decrease magnification.

For convenience in focusing or stage positioning, the pushbutton on the left permits instant 10X magnification increase or decrease from any existing magnification.

The middle pushbuttons control magnification in a fast zoom mode.

Incorporated within the system is a direct, digital readout of magnification and working distance on a three-digit LED display, as well as electronics to forward these data for printing in record micrographs.

3. Heat the Electron Gun (Tungsten Filament)

Note: Instructions for operation of the directly heated Lanthanum Hexaboride (LaB_6) filament is covered in Section four.

The following procedure is for the Tungsten Filament only.

Tungsten filament heating is accomplished by first returning the filament control knob counterclockwise against its reset stop and then turning it clockwise slowly in one continuous motion until some emission current is visible on the emission meter. During this process the F1 light will go ~~off~~, signaling the onset of emission current. on

Note: If no image appears on the Display Scope, adjust the 3 mechanical electron gun tilt screws (~~Allen head screws~~) one at a time until an image appears.

The Brightness and Contrast control knobs may have to be adjusted at this point.

4. Set the Partial/Full Select switch on partial.

OPERATING PROCEDURES

Obtaining the Electron Beam (Cont.)

5. Set the Scan Rate switch to a fast rate (1-2).
6. Use the Contrast Control knob in conjunction with the contrast meter until you obtain a high reading on the meter.
7. Use the Brightness Control knob in conjunction with the Brightness meter until you obtain a high reading on the meter.
8. Adjust the three mechanical electron gun tilt screws for maximum increase of brightness as measured on the brightness meter. Readjust meters onto scale if necessary.
9. Use the Beam Alignment knobs to further maximize the brightness.
10. Continue heating the electron gun tungsten filament by turning the Filament knob slowly clockwise.

Note:

At some point, there will be a slight dip in brightness (as indicated on the brightness meter), followed by an increase in brightness. This is normal and characteristic of tungsten emission. If the increase in brightness does not occur, further adjustment of the 3 mechanical electron gun tilt screws is required.

A plateau will be reached upon which a continued turning of the filament knob will produce no further increase brightness. The beginning of this plateau is referred to as the Saturation Point. This is the point where no further turning of the filament knob or mechanical adjustments will be required. Do not overheat.

F. Focusing the Beam onto the Specimen

As the operator proceeds towards focusing the electron beam onto the specimen, the following points should be remembered:

- a. Always maintain a satisfactory image on the display scope by adjusting the contrast, brightness and scan rate to your own viewing preference. For example, while moving the specimen, a faster scan rate (selection #1) would be appropriate. Whereas, when viewing a stationary specimen, a slower scan rate (selection #3) would be recommended.
- b. The AMRAY Scanning Electron Microscope is "PAR-FOCAL". This simply means that an area focused at any higher magnification is, by definition, focused at any lower

OPERATING PROCEDURES

Focusing the Beam Onto the Specimen (Cont.)

magnification. It is recommended that the operator avoid trying to obtain the best image at low magnification by using the Fine Focus Control.

- c. Avoid coarse excursions through focus. This is time consuming and may also result in a loss of image.
- d. Partial Field Switch may be returned to Full.

Focusing Procedure

1. At low magnification (i.e. 50X), obtain good image by turning the COARSE FOCUS control knob in either direction.
2. Increase the magnification to some higher setting, which still allows the perception of an image regardless of how blurred the image may be.
3. Sharpen this image by turning the Medium Focus control knob in either direction.
4. Increase the magnification again and obtain a good image by using the Medium and Fine Focus control knobs.
5. Decrease the magnification and examine the specimen image. The image on the display scope should now be focused to your satisfaction.

Note: Once an area of interest is located, high magnification (i.e. 20,000X) may be desired. Some optimizing of the SEM may be necessary, i.e. final aperture alignment, astigmatism correction, and spot size selection.

G. Final Aperture Alignment

If the final aperture is not properly placed on the electron beam axis, focus adjustments will cause a shift in the display scope image. This will be more severe at high magnifications. Follow the steps below in order to correct this situation.

1. Select an intermediate magnification (2000X).
2. Adjust the Medium Focus control knob approximately $\frac{1}{4}$ of a turn below and above the focused position. If the final aperture is not centered you will notice a discernable image shift.
3. While turning the Medium Focus control knob, at the same time, carefully adjust the Final Aperture control knobs 1 and 2 to eliminate the image shift.

Note: The final aperture is centered when a change in focus gives no image movement. A slight rotational movement is normal.

OPERATING PROCEDURES

H. Astigmatism Correction

Astigmatism is observed as a "smearing" of the image as it is cycled to under and over focus conditions. It is typically observed at medium and high magnifications (see figure 2.2).

Astigmatism can be corrected manually with the use of the X, Y Stigmator Controls, or with a feature of AMRAY's Scanning Electron Microscope - Auto StigTM.

Auto StigTM is designed as an automated system for stigmating the SEM.

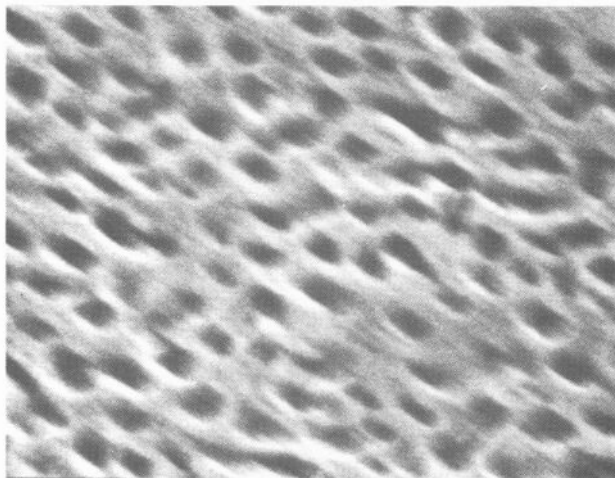
Manual Correction

1. Select a magnification of approximately 5000X.
2. Attempt to focus the image. Directional smearing of the image as it is focused is an indication that astigmatism correction is required.
3. Select the mid-point of the smearing effect.
4. Choose either the X or Y Stigmator Control and use this selected control as a fine focus control to obtain the best image.
5. Select the other Stigmator Control and again obtain the best image.
6. Return to the Focus Controls and check for the smearing effect.
7. If there is evident smearing, repeat the correction procedure.
8. If there is no evident smearing, increase to a higher magnification and repeat the correction procedure.

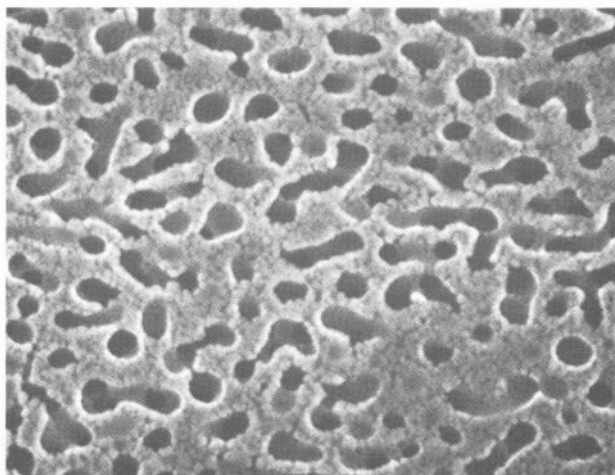
Operating the Auto StigTM

1. Select a magnification 2 to 5 times that of the desired working magnification.
2. Press the Auto StigTM button "ON".

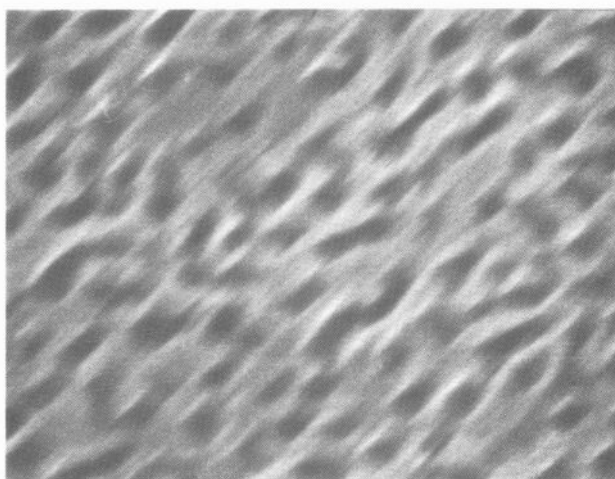
Note: An image will appear on the Display Scope as a circular vortex with a clearly defined center of sharpness.



UNDER FOCUS



CORRECT ADJUSTMENT



OVER FOCUS
MAGNIFICATION — 50,000 X

Figure 2.2

OPERATING PROCEDURES

Astigmatism Correction (Cont.)

3. Adjust Focus Controls until vortex does not have any "tail".
4. Use the X and Y Stigmator Control to position a moveable cross hair over the center of sharpness.
5. Release the Auto StigTM control button.

Note: In an instrument which has been properly cleaned and the final aperture centered, the position of the cross hair will be within the center 30% - 50% of the Display Scope.

With daily use there can be certain specimens which can contaminate the final aperture. By visually noting the position of the cross hair on a daily basis, an operator can judge when either the final aperture assembly and/or electron gun should be cleaned.

Spot Size Selection

Sharper images will be obtained at high magnification if a smaller beam size is used. Increase settings of condenser lens Spot Size Control. Signal or signal to noise ratio is reduced as beam size is made smaller.

I. Operation of the Specimen Stage

The four inch universal stage allows tilting of a five inch wafer to 70° and a four inch wafer to 90°. The specimen stage is mounted on a swing-hinge mechanism and may be lifted away for working on the bench. The operator should be aware that the maximum specimen stage tilt is a function of the specimen size, specimen holder position and working distance. Tilt is limited as a result of specimen interference with the lower pole piece of the final lens.

1. Z; (0 to 52mm) working distance - clockwise motion raises the specimen stage. The working distance (specimen to lens distance) is read directly on the LED display when the image is in focus. The motion translation is one of towards or away from the face of the display scope.
2. X Axis; (0 to 55mm), clockwise motion moves the stage mechanism parallel to the front door. This translates to essentially a horizontal movement on the display scope (if scan rotation is off).
3. Y Axis; (0 to 80mm) clockwise motion moves the stage mechanism towards the back of the specimen chamber. This translates to essentially a vertical movement on the display scope.

OPERATING PROCEDURES

Operation of the Specimen Stage (Cont.)

4. Rotation (R) Axis; (360° continuous rotation) clockwise motion produces clockwise rotation of the specimen, which results in higher angles as read on the LED Display.
5. Tilt (T) Axis; (-5° to +90°) clockwise motion produces a higher positive tilt angle.
6. L (Stage Lock) provides a means of securing the specimen stage to the specimen chamber. Vibration of the stage is thereby reduced.

Note: In addition to the above outlined stage controls, there is also a stage alarm provided within the specimen stage/chamber to warn the operator of errant stage motions. Contact of the isolated specimen area to any part of the chamber or final lens (which are at ground potential) will cause the alarm to sound. Stage motion should be stopped and a motion reversal is in order. If the specimen touches the detector collector screen, the display scope will suddenly go dark. Reversing the last motion should return the image.

J. Photography

The AMRAY Scanning Electron Microscope is equipped with a pre-focused camera assembly. As installed, the camera is adjusted for Polaroid type 52, 400 ASA film.

During installation, the record system is pre-set for average operating conditions. This allows for versatility and ease of use within the following guidelines.

1. Locate an area of interest on the specimen to be recorded on film.
2. At a magnification 2 to 5 times the ultimate desired magnification, Focus and Stigmatism as outlined previously.
3. Reduce the magnification to the desired magnification.
4. Ensure that the actual desired area of interest is appropriately positioned on the Display Scope. Repeat 2-4 if necessary.
5. Load film into the camera as follows:
 - a. Swing lever to load position (L).

OPERATING PROCEDURES

Photography (Cont.)

- b. Insert film slowly and smoothly into film holder (film indicates the side to face camera lens). A click should be heard as the holder engages the metal strip at the end of the film.
6. Select Scan Rate 1 (fastest display rate).
7. Set the Contrast Meter to zero, using the Contrast Control knob.
8. Set the Brightness Meter to zero, using the Brightness Control knob.
9. Select scan rate 3 (60 second record speed).
10. Select the Record position on the TV/Display/Record control switch. The red light next to this control switch will illuminate.
11. Pull the film envelope out until it stops. The film is now ready for exposure.
12. Push the Red Light switch to activate the scanning sequence. The red light will go out and then illuminate again at the end of the scanning sequence (approximately 60 seconds).
13. Push the envelope back into the film holder.
14. Swing the camera lever to the P position (process).
15. Using a firm, continuous motion, pull the film entirely free from the camera assembly.
16. Select the Display position on the TV/Display/Record Control Switch.
17. Allow for recommended development time (approximately 20 seconds), and then separate the film envelope using the end tabs provided (see film instructions provided in the film box).
18. Tear out the film and coat as directed in the film instructions.

Note: If your scanning electron microscope is equipped with a Video Signal Monitor, you may find it to be a useful aid in setting contrast on most specimens. A grey scale setting can be calibrated.

SECTION THREE

SPECIAL INSTRUCTIONS

SPECIAL INSTRUCTIONS

A. Video Signal Monitor

The Video Signal Monitor oscilloscope shows the instantaneous video signal in real time. The horizontal line is controlled by the X scan sawtooth waveform from the scan generator. The vertical excursion is controlled by the video signal level being displayed on the main display CRT. With no video level present, the front panel brightness control vertically offsets the horizontal line. With the horizontal line centered on the monitor CRT, the basic raster will produce a medium grey level on a micrograph. If the horizontal line was placed 2cm above center, the raster would be bright white, and 2cm below center would be dark. With video signal present, the peak-to-peak amplitude displayed on the monitor is a direct representation of signal amplitude. The greater the peak-to-peak amplitude, the higher the video contrast level on the recorded micrograph. A typical level of 2 gradations peak-to-peak, zero-centered, would give a good contrast and brightness level on a micrograph. The controls for "INTENSITY", "FOCUS", "ASTIGMATISM" of the Monitor CRT are located directly below the CRT of the monitor.

B. Second Signal Display

The Second Signal Display CRT allows the operator the capability of viewing two different detector video signals simultaneously. One detector signal will show on the primary Display Scope and another will show on the second display. The second display chassis receives its video signal at the rear via BNC connections from auxiliary detectors. The second display will also show the specimen image during the record mode. The four position "SIGNAL SELECT" switch allows the operator to choose any one of three other detectors for display, other than that being viewed on the main display CRT. The second display CRT brightness follows the brightness changes of the main display CRT when the "BR1-BR2" selector switch is in the "BR1" position. In the "BR2" position, the second display CRT brightness is independently variable via the second display "BRIGHTNESS CONTROL". The second display has its own "GAMMA" control for display of fine detail or the examination of "HOLES" without losing sensitivity of high signal levels. However, this gamma control is seldom present in the SEM.

C. Dual Magnification/Spit Screen Display System

The Dual Magnification mode of operation, selected by the "SINGLE/DUAL" switch in the upper deck, works in connection with the second display CRT system to produce simultaneous CRT images of the same subject at two different magnifications. (Note: High magnification is variable by a factor of 2 to 10 via the "PARTIAL FIELD SIZE" Control located on the Scan and Signal Control Panel).

SPECIAL INSTRUCTIONS

Dual Magnification/Split Screen Display System (Cont.)

Basic magnification full field images are displayed on the lower viewing screen, with variable "HI-MAG" displayed on the upper or second display CRT screen. Any portion of the full field display mag may be viewed on the second display CRT simply by positioning the "BRIGHT FIELD AREA" illuminated on the lower display CRT via the "PARTIAL FIELD OFFSET" Controls. Either image can be chosen for the record mode via the "LO/HI" record mode switch located on this panel.

The Split Screen mode of operation, selected by the "SINGLE/SPLIT" switch in the upper deck, permits simultaneous viewing of side-by-side images of the same specimen area produced in two different imaging modes, such as secondary on the left half and backscattered electrons on the right half of the same display CRT. The "LEFT and/or RIGHT" display select switch provides for viewing the left or right video channel alone or both simultaneously. Split-Screen "BRIGHTNESS BALANCE" Control permits the operator to match the right side brightness level to that of the left side of the display CRT.

The Dual Magnification/Split-Screen mode of operation, selected by the "SINGLE/DUAL" switch and the "SINGLE/SPLIT" switch allows the operator to view the same specimen area at two different magnifications simultaneously on the same display CRT. In this mode, the "BRIGHT FIELD AREA" is shown superimposed in the left half of the CRT and the variable "HI-MAG" image is displayed on the right half of the display CRT.

D. Scan and Signal Control Module

The Scan and Signal Control Module has the capability of modifying the standard or non-standard electron beam scanning, image viewing, and recording modes as listed below:

1. Partial Field Size consists of a single turn control for manually adjusting the size of the partial field area when the "PARTIAL/FULL" select switch is in the "PARTIAL" position.
2. Tilt Correction electronically compensates for mechanical tilt of the sample and the foreshortening effect noted in the Y axis of the image by manually allowing a variable Y magnification increase. It should be noted that this sort of image "re-stretching" produces a perspective distortion and should be used with care.
3. Invert 1 inverts the video signal to the main display CRT (light areas are displayed as dark and vice-versa). (Note: the brightness control now works backwards).

SPECIAL INSTRUCTIONS

Scan and Signal Control Module (Cont.)

4. Invert 2 inverts the video signal to the second display CRT. (Light areas are displayed as dark and vice-versa) (Note: the second display brightness control now works backwards).
5. Mix 1 & 2 combines the signal from the main display CRT with the signal on the second display CRT and presents this combined picture on the main display CRT.
6. Record 2 selects the signal from the second display CRT to be recorded on a micrograph.
7. WDS, when energized, effectively changes the condenser lens "SPOT-SIZE" selector switch range to access lower condenser lens excitations, which gives higher specimen currents, increased signal, and reduced resolution due to larger beam diameters. Typical "SPOT-SIZE" selector switch range positions in the "WDS" mode are #4 through #10. Do not use WDX in conjunction with spot size positions lower than 4.
8. SACP, when energized, removes the action of the lower set of scan coils of the double deflection scan coil system. Some field rotation will occur and the image can only be focused with the condenser lens "SPOT-SIZE" selector switch. Resolution will be extremely poor and the image will only lie within a 1cm to 3cm circle of illumination when a magnification of 20X is selected. *why?*
9. Record Integrate, when selected, provides for continuous scanning in the "RECORD" mode. Scan will stop at the end of a frame when the switch is released and the "FRAME FINISH" lamp will illuminate.
10. Lens Reversal (Condenser), when energized and then de-energized, reverses the polarity of the voltage applied to the condenser lens, which effectively minimizes hysteresis of the lens and allows a full area of illumination.

E. Electronic Systems Monitor NOT PROVIDED ON IGS UNIT (USE MANUAL CHECK)

The Electronic Systems Monitor allows the operator to check or monitor system power supplies without interrupting operation of the SEM. Power supply voltage levels are read on the "VOLTAGE LEVEL METER" and system waveforms are monitored at the BNC connection on the front panel of the monitor. (See figure 3.1) for expected readings and waveforms). (OPPOSITE - PAGE 48)

SYSTEMS MONITOR TEST FUNCTIONS

Rotary Switch Position	Waveform	DC Voltage
1	X - Scan Generator	Off
2	Y - Scan Generator	+15 Volts Vacuum System
3	X - Display Scan	-15 Volts Vacuum System
4	Y - Display Scan	+24 Volts Display Console
5	X - Scan Coil	-24 Volts Display Console
6	Y - Scan Coil	+32 Volts Lens Supply
7	Display Blanking	-100 Volts Display
8	Record Blanking	-100 Volts Record
9	Video Signal Preamp	+300 Volts Display
10	Video Signal Display	+300 Volts Record
11	Video Signal Record	-200/-1000 Volts PM Tube

Fig. 3.1

SPECIAL INSTRUCTIONS

*IGS Unit has "AUXILIARY PREAMP"
in this panel space.*

F. Microprocessor Controlled Video Signal Processor

The AMRAY microprocessor controlled video signal processor, while providing a very broad range of operating parameters and variables, is actually very straightforward to use.

1. Processor Function Control

The video signal of the SEM is routed so as to continuously pass through the Video Processor. However, no processing of any sort is performed as long as the switch labelled Processor Functions is not energized. When energized, an LED light next to the switch will glow. This control is essentially an ON-OFF control.

When the processor has been installed and calibrated, the operator uses the normal, contrast and brightness meters or Signal Monitor (CRT) settings for typical picture taking when the Video Processor is off.

2. Typical Operation

The general mode of operation and use of the Video Processor follows a simple procedure.

- a. The operator either obtains a micrograph, or observes the image on the display CRT, and decides to employ one or more functions of the processor.
- b. Either from experience or by watching the effects on the CRT, the operator will activate the processor with the Processor Function Control and make some selection of functions and levels with the Select Value and Select Function Controls.
- c. The operator then deactivates the Video Processor with the Processor Function Control and sets up the proper contrast and brightness level for normal picture taking just as if the processor were not present.
- d. The operator then activates the Processor Function Control and the Video Processor will act upon the signal, using the pre-selected values which the microprocessor remembers.
- e. - DO NOT make any adjustments of the contrast settings even though different contrast values are observed with the Video Processor on.
- DO NOT make any adjustments of the Brightness settings. Most often, depending upon the processing selected and

SPECIAL INSTRUCTIONS

Microprocessor Controlled Video Signal Processor (Cont.)

the initial electronic alignment and calibration, the Brightness level will remain the same or shift slightly. It may or may not be necessary to slightly adjust the Brightness, depending upon the functions selected and the desired result. Generally, it is not necessary to make any Brightness adjustments.

f. Photograph image.

G. Selection of Functions and Values

The Video Processor control panel is laid out so as to allow the selection of functions and values as one would select the items of interest from a table of contents or menu.

a. Select Function

A vertical array of LED lights signals the operator which function he may select. The two control buttons, one for proceeding down the array and the other for reversing to an upward path, allow the operator to stop at some function for which a value is to be selected or changed. Once a value or magnitude has been selected for any function, the microprocessor will store the selection as the operator proceeds to some other function.

b. Select Value

The two select value switches allow the operator to proceed horizontally for any function selected, in order to select essentially the magnitude of the effect to be produced. The microprocessor will store the magnitude of any function either when the processing is de-activated or when the Processor Function switch is de-energized.

H. Video Signal Processing Functions

The microprocessor controlled video signal processor allows four different types of signal control or processing which may be used separately or in combination.

a. Video Select/Mix

This function is used to select among various signal inputs, such as x-ray, ancillary backscattered electron detectors, beam induced current, etc. Using the Select Function control, one or more of the detector inputs may be mobilized. Using

SPECIAL INSTRUCTIONS

Video Signal Processing Functions (Cont.)

the Select Value Control, the operator may mix the input signal in any combination so as to obtain a composite output signal to the Display and Record CRTs. The input signals may be selected in any combination of units of $\frac{1}{4}$ or 25% of the individual detector output to a combined maximum total of 1/1 or 100%.

b. Video Enhancement

Enhancement functions generally consist of signal differentiation with a variety of time constants to control the magnitude of the effect.

1. The operator can select the type of enhancement, either First Derivative, Second Derivative, Absolute Value of the First Derivative or Absolute Value of the Second Derivative.
2. The operator may then select the Time Constant to be used from the horizontal row arbitrarily numbered 1 through 12.
3. Changes in Scan Rate - The operator will very quickly notice that the microprocessor changes the time constant value when changing the display rate speed and when the operator proceeds to Record. This allows one to observe a visual effect on the display CRT and essentially reproduce it in an image recorded at a very different rate. When selecting time constants, or trying to reproduce a value formerly used successfully, one must remember to observe the time constant LED either in record mode or at some known display rate.

Guideline Note: Some experience and the type of work being done will dictate the use of this function. However, it is most common to utilize First Derivative, with a time constant about midway from 1 to 12 (3-9).

I. Video Compression

This mode is essentially a Gamma type of processing (low level signals amplified, high level signals suppressed) for looking into holes, reducing charging effects or suppressing severe signal highlights.

1. If the operator selects Mode 1 (DC Gamma), the full frequency range of the video signal from DC to the highest frequencies will be processed.

SPECIAL INSTRUCTIONS

Video Compression (Cont.)

2. If the operator selects Mode 2 (AC Gamma), the DC OR low frequency components of the signal are discarded and only the higher frequencies are processed.
3. Either type of gamma processed video signal is then mixed with the unprocessed video signal in a proportion selected by the Compression Mix value selected. A value of 0 means no compression is used and the video signal is essentially unprocessed by the compression mode. A value of 6 means that the compressed signal is mixed with none of the uncompressed signal. One thus achieves 5 different compression functions in either of two modes.

Guideline Note: Generally the operator will use Compression Mix values in the middle of the range (2-4) using Mode 1 (DC Gamma) if one wishes to "see" into holes, etc. If one wishes to compress or eliminate the slow variations of light and dark in the picture and to display only the fine specimen detail, Mode 2 is employed. A very favorable condition is the combination of video compression and video enhancement, using First Derivative and Mode 1 compression.

d. Low Pass Filter

The low pass filter, when activated, will discard the higher frequency or "noisy" components of the video signal while passing the lower frequency components. At fast display rates, the operator will observe an apparent loss in frequency response, manifested by horizontal image stretching, but this effect will not be observed in the recorded image or at very slow display rates.

The low pass filter will be found to be useful as a focusing aid when the image signal is poor and will tend to somewhat reduce the noise level of high magnification images. (The operator must be careful not to employ the filter at low magnification,) or in any case where very fine detail is to be observed in the recorded micrographs.

J. Automatic Focus Control

This control provides for a continuous change in focus of the final lens in order to maintain the image in focus on highly tilted samples. When not in use, it should be turned to the fully counterclockwise position. In use, the control is adjusted until the focus band fills the entire screen or field of view at the

SPECIAL INSTRUCTIONS

Automatic Focus Control (Cont.)

picture taking magnification. A quick set-up procedure for auto focus is to proceed from the magnification desired for the photograph to some magnification at least three times higher. Focus and stigmatize normally. Next, drop down to the lower picture taking magnification and position a partial field area at the bottom of the CRT, via the "PARTIAL FIELD OFFSET" dual control, and bring the now out of focus image into focus with the "AUTOFOCUS" Control. Return the "FULL/PARTIAL" field selector switch to "FULL" field position and the entire field of view will be in focus.

Use of the Raster Rotation System

The "SCAN ROTATION" Control electronically rotates the scanned raster or scan line on the specimen surface to any orientation over a 360° range. It is microprocessor, digitally controlled, and the rotation angle is illustrated on the LED readout which normally displays the acceleration potential of the electron gun when the momentary toggle switch, located directly above the LED readout, is depressed to the left. Depressing the switch to the left a second time returns the LED display to readout of the acceleration potential. At any time, the operator can automatically return to 0° raster rotation by depressing the momentary toggle switch located above the "DIGITAL MAGNIFICATION READOUT" LED, to the right. The zero-degree LED, located to the right of this switch, will illuminate, confirming 0° raster rotation.

K. Alphanumeric Digital Printout

General

The Alphanumeric Digital Printout system offers three primary operating modes which may be used separately or in combination to perform a variety of data recording tasks in the SEM laboratory.

1. Automatic Micrograph Annotation

Vital data relating to the interpretation and indexing of each individual image is computed and formatted for display on the viewing CRT or television monitor, and printed clearly on the bottom of the recorded micrograph during the normal film exposure process. Standard data fields include beam acceleration voltage (to 0.1 kv), image magnification, micron marker scale factor, eight-digit specimen ID number (or optional logo), and four-digit sequential frame number. All displays are corrected for split-screen, dual magnification, and television image format.

SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout (Cont.)

2. Keyboard Annotation (Optional)

Arbitrary alphanumeric data may be superimposed anywhere on the full-screen image by means of a standard teletype keyboard and moveable video-generated cursor. Typed symbols may be chosen from a large (127) character set including all the standard typewriter characters and many special scientific symbols, including most of the Greek alphabet. A set of special control codes permits simple cursor manipulation, screen display of the special symbols and selective erasure of the screen. The typed data may be recorded on the micrograph or videotaped exactly as it appears on the screen.

3. Particle Measurement (With Keyboard system only)

The particle measurement mode is selected by the toggle switch labelled PMS, when the CRT and AUTO switches are both enabled on the keyboard. A special horizontal marker, called the PMS micrometer, will appear on the screen, similar in appearance to the micron marker. The length and position of the micrometer can be adjusted to match various image features, using the three knobs on the right side of the keyboard enclosure marked X1, X2, and Y. Controls X1 and X2 set the horizontal position and length of the micrometer respectively, while control Y sets the micrometer's vertical position.

The actual distance on the specimen, represented by the length of the PMS micrometer in the magnified image, is computed continuously and reported automatically in the third data field at the bottom of the screen, preceded by a Greek "delta". Like the micron marker, the PMS micrometer is appropriately scaled in units of mm, um, or nm. Note that the measurement is made using the outside edges of the micrometer.

4. Operating Instructions

The Keyboard/Alphanumeric circuits are powered whenever the main CONSOLE switch is on. In general, proper functioning of the system is indicated to the operator by appropriate response of the front panel Digital Magnification Readout to the mag control pushbuttons. When first powered on, the display will show three dashes until the gun high voltage setting is entered.

The four major controls of the CRT alphanumeric display are toggle switches located on the keyboard enclosure built into the table top of the control console directly below the viewing CRT. Each switch is equipped with a red pilot light to improve visibility in low light conditions.

SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout (Cont.)

- CRT - The master switch for all video display modes. Turning off the switch does not erase or alter the stored data, but inhibits its display on the screen.
- AUTO - Selects the automatic annotation mode.
- KB - Selects the keyboard annotation mode. The full ASCII keyboard is enabled.
- PMS - Selects the particle measurement mode. The controls marked X1, X2, and Y are used for PMS.

In addition, there is a momentary-action toggle switch just above the front panel LED readout which, when pressed to the left, will change the readout mode alternately between magnification and working distance. The yellow "WD" lamp indicates working distance mode.

Note: Instruments not equipped with keyboards have access only to the AUTO display mode and its associated data field, with data entry via a 12-button keypad mounted in the upper deck of the SEM control console. A full explanation of this system will be found at the end of this part.

5. Automatic Annotation Mode

The automatic micrograph annotation mode is selected by the AUTO toggle switch and displayed when the CRT switch is enabled. An example of a Type 52 Polaroid image annotated by the 1610/1645 is shown in figure 3.2. At the bottom is a line of 3mm characters, white on a uniform black background which occupies the lowermost 8mm of the image area. Directly above the lettering in the black field is a horizontal white bar, called the micron marker, the length of which indicates the scale of the recorded image. The data is arranged in five groups as follows:

- a. Image Magnification: Three significant figures with trailing zeros, preceded by "X". Magnifications are calculated for the 4 x 5 inch standard camera format. The CRT display operates at about 30% greater magnification. In TV mode, magnification is proportional to monitor size, but the micron marker is always applicable, regardless of image enlargement factor.
- b. Electron Beam Acceleration Potential (kilovolts).

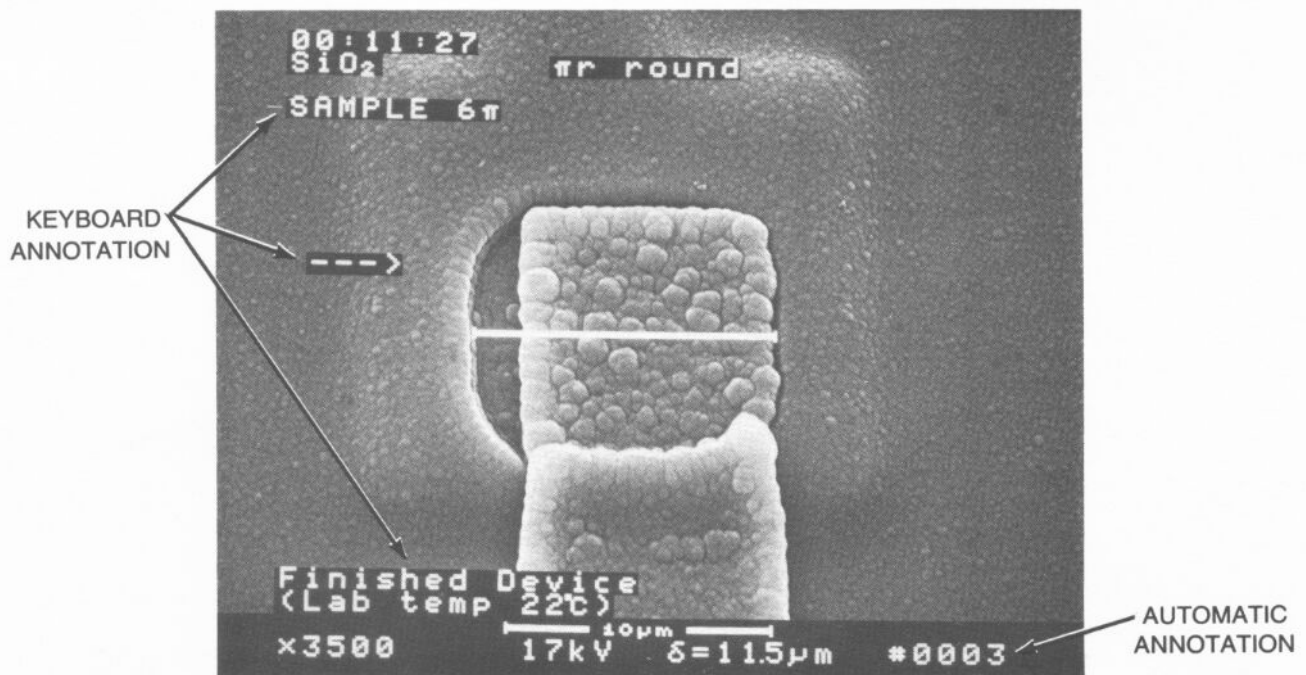


Figure 3.2

SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout

- c. Logo: Any eight (factory installed) ASCII characters to be automatically entered by the system on power-up. This field is also used to display the measurement value in the particle measurement mode; in PMS the logo is not shown. This field will be similarly pre-empted in the dual magnification display format. Logo display may be permanently inhibited (by internal switch S2 on PC9M), leaving blank spaces, or the data field may be used for keyboard data entry.
- d. Frame Number: A selectable four-digit number which will increment automatically with each record exposure. Date entry is via keyboard or keypad command sequence.
- e. Micron Marker Scale Factor: Located within or to one side of the micron marker, indicates actual distance on specimen represented by length of marker on the image. Scale factor is always a power-of-ten (mm, um, or nm).

6. Stopwatch Timer Mode

The uppermost line of characters on the screen is reserved for display of elapsed time in hours/minutes/seconds format. The timer may be started, reset, displayed or hidden by commands from the keyboard. See summary of keyboard control characters.

7. Keyboard Data Entry System (figure 3.3)

The keyboard annotation mode is selected by the KB switch when the CRT is enabled, permitting storage and display of typed in information. Any symbol appearing on the typewriter keyboard (plus a number of others) may be entered into any of 30 locations in each of 25 lines covering most of the CRT area. All upper and lower case letters, numbers, punctuation marks and mathematical symbols are included in the expanded character set, plus most of the Greek alphabet. Turning off the KB switch does not erase stored data, but inhibits its appearance on the screen. All typed data will be lost, however, when the main console is depowered. Keyboard entry of characters is disabled in PMS mode.

An example of the keyboard-annotated micrograph is shown in figure 3.2. Each typed symbol appears white in its own black background box, interrupting the normal video image. The current valid arrangement of data is stored in semiconductor memory and read out during each frame scan, except in display scan rates 1 and 2. A white block called the cursor indicates the location at which the next typed character will appear. To enter information at a particular location on the screen, it



Figure 3.3

SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout (Cont.)

is first necessary to position the cursor at that point, using one or more of the special cursor manipulation commands (listed on the following pages). The cursor may be moved forward, backward, up, down, or diagonally, one character at a time, or it can be tabbed vertically or horizontally. Typed characters may be erased one at a time or in blocks, or the entire screen cleared. Access to the reserved data fields and the alternate character set are likewise gained via special commands, most involving the CONTROL key.

A display of the special symbols not appearing on the keyboard (the alternate character set) may be brought to the screen by typing CONTROL - F. Each special symbol is associated with the letter just above it, and may be entered by typing ALT MODE, followed by its corresponding letter. For example, the Angstrom unit symbol is entered by typing CONTROL-A.



SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout (Cont.)

Keyboard Control Characters

@ = hold CONTROL key

@A	cursor left
@B	load data field (start/stop)
@C	cursor down + right
@D	cursor right
@E	cursor up + right
@F	display alternate character set
@H	cursor home
@I	tab cursor
@L	caps lock/unlock
@N	load frame number (start/stop)
@P	display test pattern
@Q	cursor up + left
@R	reset timer
@T	start timer
@U	black tab cursor
@W	cursor up
@X	cursor down
@Y	erase timer
@Z	cursor down + left
RETURN	cursor down, begin next line
LINE FEED	cursor down four lines
RUB OUT	erase previous character
PAGE	erase screen
BREAK	erase contiguous field
ALT MODE, (Number)	subscripts
ALT MODE, (Letter)	alternate characters
ALT MODE, RESET	software reset

Q	W	E
A	CURSOR CONTROL	D
Z	X	C

SPECIAL INSTRUCTIONS

Alphanumeric Digital Printout (Cont.)

Keypad System

An instrument equipped with the upper-deck keypad module in place of the full keyboard will operate only in the AUTO mode, when the CRT pushbutton is enabled. The keypad permits entry of numeric data into the third (logo) and fourth (frame number) data fields. Field selection is by means of the "*" and "#" telephone symbol keys on the 12-button keypad.

To enter keypad data into third data field:

1. Press "*" key to begin entry. Cursor will appear at beginning of third data field. Any logo entered previously on power-up will be erased.
2. Enter numbers as on a calculator. The "#" key may now be used to enter a "/" character for dates.
3. Press "*" key again to conclude entry. Cursor will disappear from third data field.

To enter keypad data into fourth data field:

1. Press "#" key to begin entry. Cursor will appear at beginning of fourth data field.
2. Enter up to four numbers as on a calculator.
3. Press "#" key again to conclude entry. Cursor will disappear from fourth data field.

L. Instrument Standardization and Analysis

Aside from the traditional resolution tests on standard samples, quantitative measurement methods for assessing the performance potential and cleanliness of SEM systems has generally been vague and subjective. The need for some measurable, recordable and reproducible technique, whereby deviations from the norm can be detected, is clear. Such a method would be helpful to both the operator and service personnel alike. Operators of AMRAY SEMs are encouraged to adopt a technique called "Magic Number" generation, which was developed by AMRAY to fulfill this need. If performed on a routine day-to-day basis, an accurate record of the microscope's performance potential can be maintained.

1. The Magic Number Generation Technique

The Magic Number Generation technique can readily be performed on all AMRAY SEMs without adaptation or modification. The Magic Number generation method is a technique whereby

SPECIAL INSTRUCTIONS

Instrument Standardization and Analysis (Cont.)

the operator measures the amount of gain required by the photomultiplier tube (PMT) to produce a video signal of specific intensity.

An increase in the Magic Number above some predetermined baseline level results directly from a loss of signal and indicates that an inquiry into the cause is warranted. Possible causes may be contamination of an aperture, dirty column or gun, etc. The actual number produced by this method is not of importance since different microscopes may have widely different numbers; it is the reproducibility that is of concern, and whether or not the number has increased over the base level.

It is important that the conditions under which the Magic Number is generated be reproduced each time. It is not important whether 20KV, 25KV or 30KV is used - just that it be used every time.

Standardization of the AMRAY 1610/1645 Scanning Electron Microscope

- I. Specimen
Clean Gold Grid, 45 degrees tilt, 12mm W.D.
Etching solution: 3HCl, 1 HNO₃, 4H₂O, 20-40 seconds, water flush, alcohol flush, dry
- II. Electron Gun: 20kv^{*} ~~30kv~~, 100ua Emission [IGS - we use 20kv.]
- III. Condenser Lenses: Spotsizes 6
- IV. Apertures: Column: 300u
Anode: 300u
Final: 200u
- V. Mode: Secondary Electrons, Signal Select Switch to Position A.
- VI. Magnification: 10-20,000X focus and stigmat, finally 5,000X Grid only in field.
- VII. Measurements: Set Brightness and Contrast meters to "0" and note position of contrast knob. Rotate contrast knob maximum counter-clockwise and measure number of turns to nearest 1/8 turn. This is your Magic Number.

* Training Manual says 20kv

4.75

Magic
#

SPECIAL INSTRUCTIONS

Instrument Standardization and Analysis (Cont.)

The procedure for obtaining a Magic Number is relatively quick and simple. With the appropriate gold mesh grid sample in the microscope and the above listed conditions satisfied, proceed as follows:

Select an area where the gold grid bars intersect. At 5,000X, this cross-section area should just about fill the CRT. Increase magnification to 20,000X and focus and stigmatize. Return to 5,000X. At the fastest display scan rate, use the Contrast and Brightness Controls to set both meters to "0" (zero). Select a fiduciary point on the Contrast control knob and note position. Turn Contrast knob counter-clockwise, noting the number of turns until it stops. Record the number of turns to the nearest 1/8 turn. This is your SEMs Magic Number.

2. Interpretation of "Magic Number"

Determining what your Magic Number means and how to use it is important. If an SEM system is clean and at optimum performance, all available signal is utilized and hence, a baseline Magic Number is produced. As the system deteriorates from the optimum or ideal, signal is lost and is subsequently reflected as a higher Magic Number. The amount of increase considered insignificant depends on the magnification range desired by the operator, and concurrently, by the amount of signal required. Since one full turn of the contrast (gain) control represents approximately a factor of 3 in signal amplification, $\frac{1}{4}$ turn deviation becomes significant for good performance at 50,000X and higher. At 5,000X magnification, even $\frac{1}{2}$ turn increase may not adversely affect performance. Thus, the frequency of cleaning as determined by the Magic Number depends on the operator's expectations and requirements.

As an example, suppose a microscope has a baseline Magic Number of $4\frac{1}{8}$ and on this occasion, the operator determines the Magic Number to be $4\frac{3}{8}$. Since an increase of $\frac{1}{4}$ turn or more is significant (for high magnification), the loss of signal indicated by the higher Magic Number is real. This should prompt the operator into a logical, sequential investigation of the cause. If contamination of the final aperture was suspected, the operator could confirm or deny this supposition by cleaning the aperture and again checking the Magic Number. If the number returns to normal, proceed no further. If the number remains high, the problem lies elsewhere.

SPECIAL INSTRUCTIONS

Instrument Standardization and Analysis (Cont.)

Actual field experience has shown that the likelihood of involvement as a contributing factor in signal loss is as follows:

X → Electron Gun- 70%, Final Apertures- 20%, Column Liner- 10%

METALSPRAYS
SEM

{ In Ion-pumped emission chamber systems, the electron gun requires less frequent cleaning and these percentages are rearranged as follows:

✓ → Final Apertures- 70%, Electron Gun- 20%, Column Liner- 10%

Typically, the column liner is cleaned by operators far more than needed in an attempt to retrieve lost signal.

It is possible, too, that with time and careful repeated cleaning, the Magic Number may improve (become lower). If the improvement is real (not due to operator error), then a new baseline has been established for future comparison.

3. Conclusion

Routine
monitoring
of performance.

Deviations from the ideal in SEM systems produces a concomitant loss of signal. By routinely measuring the amount of gain required to produce a video signal of specific intensity under standardized conditions, it is possible to indirectly assess the performance potential of the microscope. Recording the Magic Number on a routine basis will provide both operators and service personnel with a useful record of the instrument's performance level and condition.

M. Low K.V. Operation with Semiconductor Applications

1. Introduction

Major applications of the SEM to the testing of semiconductors are:

- Wafer Inspection and Mask Inspection.
- Line Width Measurements on Wafers and Masks.
- Voltage Contrast on packaged devices and wafers.

To avoid radiation damage to the semiconductor materials and charging of the mostly non-conductive photoresist surfaces, it is important that beam energies be kept at minimum practical values, usually between 500 and 2500 electron volts. For most nonconductive specimen materials, an ideal beam energy (KV) can be found where the secondary electron emission volume results in a near zero electron presence on the surface of the sample, thus minimizing charging.

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

2. SEM Instrument Factors for Low Beam Energy Operation

Electron Source

Advantage of LaB_6 over tungsten cathodes for low energy beams.

- Increased brightness leads to at least a tenfold improvement in signal to noise ratio of image for comparable operating parameters.
- Reduced source diameter leads to smaller spot sizes and better resolution for comparable operating parameters.
- Reduced energy spread of electron beam leads to smaller circle of confusion in final beam diameter for a given chromatic aberration factor (C_c) of final lens.
- Optimized Electron Extraction Field at Source for low Energy Beam.

A strong electron extraction field is achieved between Wehnelt Cap and anode in order to maintain source brightness of low energy beams.

3. Objective Lens Parameters

"Spherical aberration" and "chromatic aberration" influence the ability of the lens to focus off axis electrons on the plane of the object, thus impairing effective spot size and resolution. Both parameters improve (decrease) with shorter working distance of the final lens. Further improvement in the influence of C_s on spot size is obtained by decreasing the aperture angle of the beam by means of a smaller final aperture.

4. Detection Systems

The electron optical performance advantages of short working distance with large samples is often compromised by the inability of the conventional secondary electron detector's collection field to effectively project into the small space between sample and final lens. This leads to reduced secondary electron collection and a poor signal to noise ratio of the image.

5. SEM Operation at Low KV

For those applications relating to the semiconductor industry, specimens usually contain non-conductors, such

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

as photoresist (a type of plastic), oxides (silicon oxide, nitride) present in bulk or a surface layer, etc., as well as semiconductors, such as silicon, germanium, gallium arsenide, etc. Also, in many cases, the customer cannot coat his specimens with evaporated or sputtered coatings, such as gold. This may be due to the fact that he may wish to continue the processing steps on silicon wafers, or for electrical reasons, or for reasons that he is not willing to state. Samples may be in the form of thin wafers, broken wafers, or finished devices in dual in-line packages.

As a result of these constraints, low kv operation of the SEM (800 volts to 2.5KV) is usually indicated since specimen charging may be reduced or eliminated, and electrical damage to the specimen (such as MOS devices) is also reduced.

Although it is well known that the resolution of SEMs is generally not as good at low KV as at high KV, reasonable pictures of good quality can be obtained in the low KV ranges, even on older SEMs operating in the field which have never been used below 10KV.

The following is an outline of proper operating parameters which should be used to obtain good quality, low KV images (normally in the range of 800 volts to 2.5 KV).

6. SEM Operating Parameters for Low KV Micrographs

- KV
The range of gun voltage, which is pertinent to "low KV", is from about 800 volts to 2.5 KV. Below 700 volts resolution and signal will be limited, and above 2.5 KV, we are really beginning to leave the KV range which we call "low KV".
- Filament. (Note: Also see pg's. 75-80)
Utilization of the LaB₆ source (with Ion Pump) produces very high quality low KV pictures. This is due to the fact that the energy spread of the electrons is less and also the source is brighter (more electrons). However, the conventional tungsten source can be used for low KV imaging, but a poorer signal to noise ratio and resolution should be anticipated.

W or LaB₆
Filaments

The gun (wehnelt cap and gun aperture), whether tungsten or LaB₆, should be clean and the filament spaced properly

The LaB₆ source, preferred for use at low KV must be centered and spaced properly in the Wehnelt cap. Most

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

LaB₆ filaments available today are single crystal emitting sources with the crystal located at the tip of the filament. A compound microscope with micrometer is essential for setting the proper distance between tip and wehnelt surface. Optimum spacing of the emitting crystal is in the range of 220 - 245 u back from the outside surface of the LaB₆ removable aperture. Although the filament has a single emitting crystal, there may exist other secondary crystals or artifacts which the operator should be aware of which may emit electrons. The lower magnification dissecting or stereo microscope is very useful for centering the filament, there by narrowing the region where the tip of the crystal should be searched for. Critical alignment and spacing should be done in a compound microscope with calibrated stage height vernier at a power of 200X. (The tungsten filament is generally spaced 125 to 140u from the outside surface of the "top hat" aperture).

- Wehnelt Cap to Anode Distance

N.B. → This is one of the most important operating variables (if not the most important) to be considered for obtaining good quality low KV images. In the past, operators were encouraged to set the Wehnelt to anode distance at 11 or 12 mm for 30KV and to leave it at this height. This distance is changeable (even externally) in the case of LaB₆/ion pumped emission chambers (see below). If the SEM has only a fixed anode distance capability, spacers should be considered for improving low KV performance.

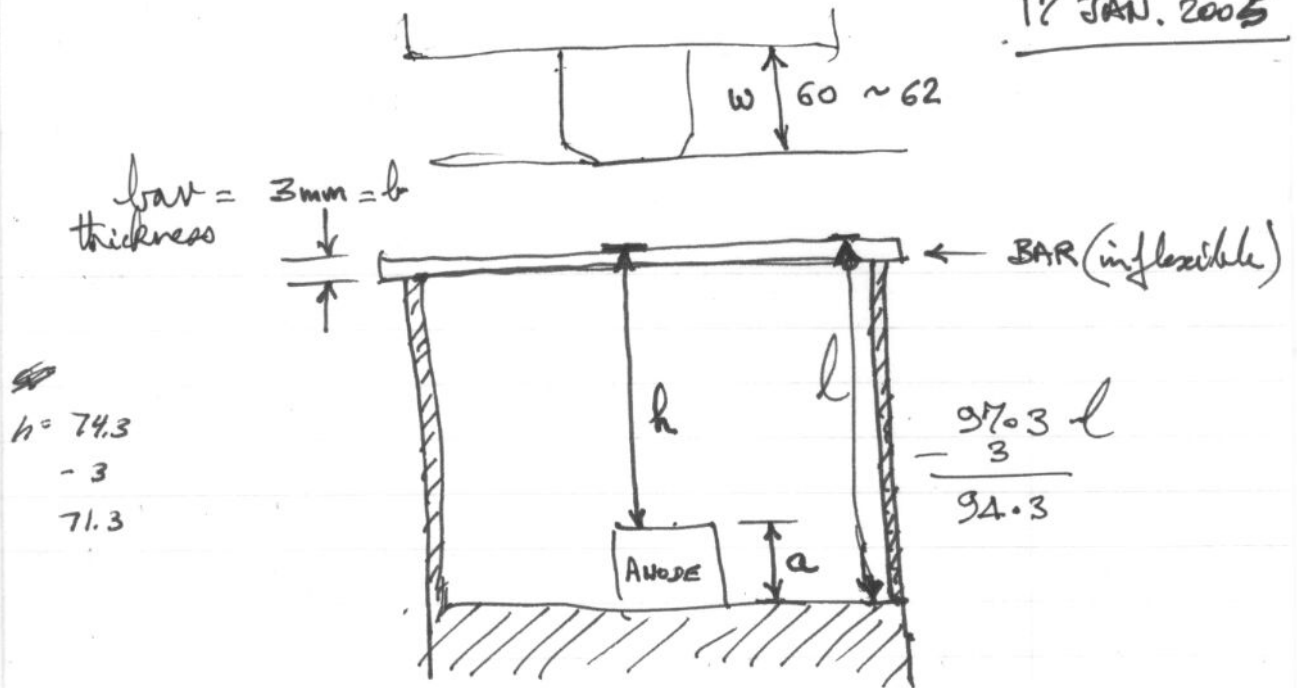
Based on recent investigations, AMRAY is now recommending the following Wehnelt to anode distances:

- 6 mm
- 1 - 3 KV range: 3mm ($\pm \frac{1}{2}$ mm)
 - 5 - 10 KV range: 4mm ($\pm \frac{1}{2}$ mm)
 - 20 - 30 KV range: 6mm ($\pm \frac{1}{2}$ mm)
 - 40 - 50 KV range: 9mm ($\pm \frac{1}{2}$ mm)

These distances are guidelines only and can vary by about 1mm with essentially no effect on image quality, but please note the following suggestions:

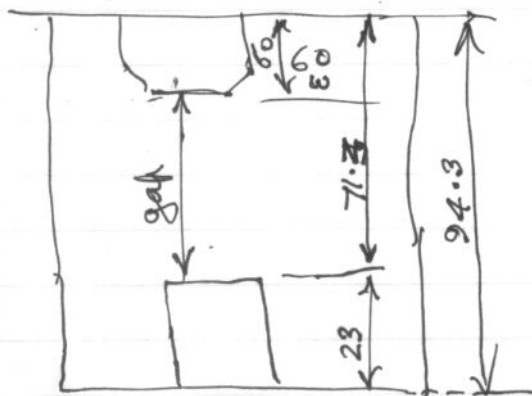
- a. Never use a distance shorter than about 2.5mm (even at voltages less than 700V). The voltage gradient is distorted by the close distance between the Wehnelt cap hole and the anode hole.
- b. At 25-30KV Wehnelt to anode distances shorter than 6mm will usually cause arcing (black streaks in the image), even in ion-pumped systems.

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$h = 74.3 \text{ mm}$ when removed. $(74.3 - 3.0) = 71.4$
Place Bar

Hehmet Cylinder Aperture has wipers inside the Aperture and the surface appears "blacker" than a new one which is more silvery. — Replace with new Aperture.



$$\begin{array}{r} 97.3 \\ 74.4 \\ \hline 23. \\ 3 \end{array}$$

$$\text{gap} = 11.3$$

Brought Anode Up, about 3mm such that $h = 71.5$
subtract $b = 3.0$

$$\begin{array}{r} 68.5 \\ \text{subtract } w = 62 \\ \hline \text{gap} \approx 6.5 \text{ mm} \end{array}$$

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

- c. If the anode distance has been reset by opening the emission chamber (see below), allow the system to pump down to a good vacuum (better than 300 microamps with ion-pump) before going to 30KV. Start operation at 10-15 KV and allow the system to warm up and de-gas for 15 minutes to 2 hours to prevent arcing. Proceed to 30KV in 5KV steps every 5 to 10 minutes or so after initial operation at 10 to 15 KV.

If any instability is noted, drop the KV down and continue operation until the KV can be raised without instability. Once the system is stable, the gun can be operated directly on succeeding days at 30 KV or higher, as long as the emission chamber is not vented.

Setting Anode Height

A good procedure for permitting external anode to Wehnelt distance adjustment on LaB₆/ion pumped systems during operation is as follows:

NOTE

- a. Vent gun chamber and tighten three gun tilt screws until the adjustment ring is essentially in contact with the emission chamber cap.
- b. Set the Wehnelt to anode distance to 2.5 to 3mm with the threaded anode support.
- c. Re-pump system, energize gun, and filament at 1-3KV. Mechanically and electromagnetically align, keeping the distance between the adjustment ring and the emission chamber cap at about $\frac{1}{2}$ mm.

If one screw bottoms out, or cap is slightly tilted, operate with about $\frac{1}{2}$ turn of adjustment on this screw. The system can operate this way in the range of 500 volts to 3 or 4KV.

- d. If the operator wishes to raise the KV to 10, 20, or 30KV, he simply backs off the tilt adjustment screws, while keeping an image and adjusting for good signal as the KV is increased. The Wehnelt to anode distance is equal to 2-3mm (initial internal setting), plus the height of the gap which appears between the adjustment ring and the emission chamber cap as the tilt screws are loosened. The gap is easily measured to $\pm\frac{1}{2}$ mm, even if the adjustment ring is slightly tilted.

Note: See section on filament heat for saturation.

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

- Emission Current

At 30 KV a typical, appropriate, gun emission current is of the order of 100 to 150 micro amps. If the anode is set to about 3mm for the 1KV range of operation, the bias voltage control will allow smooth control of emission current up to about 150 microamps.

However, best resolution at 1KV is obtained if the emission is limited to 50-75 microamps or less.

It will usually be observed that the signal does not improve at 1KV if the emission is increased to 150 microamps (with the bias control) and, in any event, the resolution will typically show a tendency to degrade as the electrons repel each other at the crossover between the filament and anode. As the crossover gets bigger, the resolution and signal to noise ratio gets poorer. This is the case with low energy electrons (about 1KV), but is less important at 20KV or 30KV where the electrons do not repel each other as easily.

- Filament Heating Current and Saturation

The most common cause of short filament life, and especially premature burnout of LaB₆ sources, is overheating. It is especially important to note that the filament heat required for low KV operation is significantly lower than that required for saturation at 20 or 30KV. As an example, if the filament saturated at a rheostat setting of 5½ to 6½ at 30KV, saturation at 1KV could be as low as 4 to 5 on the filament heat rheostat. This is true for both W and LaB₆. In addition, LaB₆ sources will generally saturate at lower heat settings than tungsten.

- Indications of Filament Saturation

Saturation does not produce as sharp a change in signal at low KV as at high KV and, in addition, saturation of LaB₆ sources is also less "sharp" than W sources. It is common to observe the signal continuing to increase as the filament heat is raised to dangerous levels. The following guidelines should be observed.

- a. For LaB₆, and even for tungsten, operate at as low a filament heat as necessary to produce images which are signal stable and good quality. When first saturating, keep trying lower filament heats until large drops in emission current and signal are

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

observed. Operate at as low a heat as possible. Also, the filament heat can usually be lowered after the gun has been operated for 15 to 30 minutes. In any event, do not try to continue to heat the filament in an attempt to push the last little bit of signal out. The images will not be improved and the filament will be short lived.

- b. Another way to recognize when saturation has been reached is to observe the emission current as the KV is changed. When the filament is saturated, the emission current is proportional to KV.

Example: At 1KV, the emission current is observed to be 60 microamps. If we switch to 2KV, the emission current will now be in the range of 120 microamps. The filament is now saturated and no more heat need be applied. The filament is operating properly for the range of 700 to 2KV. It will definitely be under-saturated for 20 and 30KV. If we change from 20 to 30KV, the emission current should be in the ratio of 2 to 3 (100 to 150 microamps, as an example). Even with this method, try to keep the filament heat down. The proper emission current ratio will also be observed when the filament is } NOTE
BEWARE
overheated or "oversaturated".

- Working Distance

At low KV, resolution will improve as the working distance is shortened, just as at high KV. Of course the working distance will be limited by sample size and the sample tilt required. There will always be a compromise between resolution, tilt, working distance and signal. In general, shorter working distances are best. If you can operate at 3 or 4mm W.D., do so.

- Sample Tilt

A unique situation is observed with sample tilting in the case of low KV operation on uncoated, non-conductive specimens such as photoresist on oxide, glass masks for semiconductor manufacturing (without photoresist), and for other samples of this nature. If these kind of samples are observed at low tilts in the range of 0 to 15 degrees with beam energies of the order of 1 to 2KV, they may exhibit charging or unusual contrast conditions. If the samples are tilted to about 45°, charging will often be eliminated and the KV can be increased.

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

Therefore, whenever possible, tilt these kind of samples to angles of the order of 45° and attempt higher KV (i.e., 1.8 or 2KV compared to 1.0 or 1.2KV). If the sample is conductive, as in the case of highly metalized or finished semiconductor devices, or if it is coated, the higher tilt may not be necessary and perhaps a shorter working distance can be achieved.

If the sample cannot be tilted, and is non-conducting, then charging will probably occur unless the KV is lowered to about 1.0KV or less. The operator must explore to determine the proper operating conditions.

- Final Lens Aperture

A 200 micron aperture in the final lens is most appropriate for good quality micrographs at low KV. It is very rare that a 100 micron aperture will yield a better micrograph at low KV. However, at magnifications of 10X to 3000X or so, where resolution is not a problem, a small aperture (100 microns) can be used to obtain better depth at focus where the sample topography is extensive. Use of the autofocus (dynamic changing of final lens current during the Y scan) is also good to try.

- Condenser Lens

Operation of the condenser lens (spot size) control is similar to that at high KV. If the condenser lens is driven to produce short focal lengths (high spot size number), the resolution is improved, but the signal and signal to noise ratio is poorer. One chooses the highest spot size number possible which will yield an image which has good resolution, but is not too "noisy" (poor signal to noise ratio). At low KV, for magnification in the 5000 to 20,000X range, typically spot size numbers are in the range of 6 to 10. Very seldom are spot sizes above 10-12 useful, unless the sample is unusually good.

Remember, the best images may be those which are integrated well, rather than those using smaller beam diameters with lower incident current and therefore, less signal.

Example: A 1KV micrograph taken at 12,000X, at spot size 9 or 10, could reveal better structure than one taken at spot size 11 or 12. Again, we must explore for the best operating conditions.

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

- Picture Integration Time (Record Scan Rate)

Long record scan rates produce the best pictures. If there are no signs of contamination or charging, better image resolution is obtained at longer picture taking times. Record at 120 to 150 seconds, rather than 40-50 seconds.

- Typical Magnification Range

Since the best resolution we can expect in the 1KV to 2KV range is about 150 to 250A, pictures at 10,000 to 15,000X usually will represent the limit of sharpness. Even if a little bit of "empty magnification" is permissible, it is very rare to see sharp micrographs in this KV range higher in magnification than 20,000 to 30,000X.

- Sample Orientation and Geometry

Except in special cases of linewidth measurement or voltage contrast, if we are trying to obtain a good micrograph in the low KV range, we generally have the freedom to "compose" a pleasing, good-looking, image.

As a typical example, if we are trying to photograph photoresist or etched structures, we will quite often be looking at lines or pads which project out of the sample surface. At the ends of these pads or lines, we can "see" the top of the structures, the edges and the surface or structure they are sitting on. The most pleasing and informative geometry is a 45° sample tilt with the edges of the structure running in a direction from "corner to corner" on the micrograph. If two edges of the structure, which are perpendicular to each other, can both be seen, it is important to balance the signal or "illumination" on both edges such that they are nearly equal. This is done by "mechanical rotation" of the specimen until the signals from each edge are roughly similar. This rotation will depend upon the location of the detector and the orientation of the structures of interest. After the signals are balanced, scan rotation can be used to obtain a micrograph which "pleases the eye".

- Video Signal Processor

It is quite often useful to use the "Low Pass Filter" function of the video Signal Processor to suppress the appearance of "noise" in the record image.

SPECIAL INSTRUCTIONS

Low K.V. Operation with Semiconductor Applications (Cont.)

- Guidelines for High Quality Micrographs at Low KV

In order to obtain high quality micrographs at low KV (700 to 2.5KV), the following operating variables, in approximate order of importance, must be considered.

- a. Short Wehnelt Cap/Anode Distance (approx. 3mm).
- b. LaB_6 source.
- c. Emission Current under, or about, 50-75 microamps.
- d. Short working distance, if possible.
- e. Higher sample tilt (45°) compared to low tilt ($10-20^\circ$).
- f. 200 micron final lens aperture.
- g. Longer record exposure times. Possibly use "Low Pass Filter" and lower spot size number to integrate image.
- h. Pleasing sample orientation.
- i. Reduced filament heat - Do not oversaturate-primarily for long, stable source life.

SECTION FOUR

OPTIONS AND ACCESSORIES

OPTIONS AND ACCESSORIES

A. Operation of the Lanthanum Hexaboride (LaB₆) Source Note: Also see pages 66-70

Extended lifetime with excellent stability and brightness have been obtained from the directly heated LaB₆ gun source in conjunction with the use of Vac-Ion pumping of the emission chamber in AMRAY SEMs. The source consists of a pointed LaB₆ rod suitably supported. The filament base is identical to that used for the standard tungsten filament source. In general, it must be remembered that the source is quite fragile, mechanically, and must never be subjected to rough treatment.

- I. Before attempting to install the LaB₆ source, you should make note of the following items to be able to know when you have obtained proper operation of your LaB₆ source.
 - a. Standard saturation of a tungsten filament.
Record the filament heat dial setting as accurately as possible (see section III).
 - b. With standard conditions set, take a "magic number" as follows:
 1. 100 u amp emission.
 2. Spot size 6.
 3. 20 K.V.
 4. 200 u final aperture.
 5. 45° tilt (gold grid specimen).
 6. 5000X so that gold grid fills entire viewing field.
 7. Focus the image and stigmat at 20,000 to 50,000 times.
 8. Set contrast and brightness meters to "0" and "0" respectively.
 9. Record number of turns remaining on contrast control from point in step 8 to maximum counter-clockwise.

New Wehnelt Cap

Before installing the LaB₆ in the Wehnelt cap, make sure the new cap fits smoothly, does not twist the filament posts, and can easily be installed or removed. Check for proper connection of the electrical contacts in the filament support posts. If there is any question, see your field service engineer.

OPTIONS AND ACCESSORIES

Operation of the Lanthanum Hexaboride (LaB_6) Assembly (Cont.)

The gun cap (Wehnelt cap) must be replaced with a cap designed specifically for use with the LaB_6 source. Internal dimensions of the standard tungsten source cap are such that attempts to utilize a LaB_6 filament in the standard cap probably will result in breaking the filament upon assembly into the cap.

A sketch of the proper gun cap is shown in Figure 4.1A for tungsten and 4.1B for LaB_6 . Note that the design is such that it is possible to remove the Wehnelt aperture insert without removing the filament. This is necessary to allow cleaning or realignment without unnecessary handling of the filament itself.

Inserting the Filament into the Gun Cap

The LaB_6 filament is inserted into the gun cap in the normal manner. However, to avoid breakage of the filament, the Wehnelt aperture should be removed such that the entire front of the cap is open. Once the filament is inserted, back it away from the front far enough to insure that when the aperture is inserted the LaB_6 tip will not be touched. Preliminary rough centering of the tip may be done at this time.

Centering the tip of the LaB_6 rod is accomplished with the three centering adjustments in the gun cap in the normal manner (see tungsten filament). Use of a low power stereo microscope will allow visualization of the tip through the aperture opening.

The adjustment of the distance back of the LaB_6 tip from the front of the Wehnelt aperture is quite critical and is best measured with a light microscope at 100 to 200X using vertical illumination and a Z travel stage calibrated in microns. Metallographic microscopes possess the necessary illumination and calibrated focusing controls for such measurements. If a microscope is available which uses only transmitted light illumination, it is possible to utilize an auxiliary light source, with the light somewhat oblique to the gun cap. It is important to remember that each notch on the outside of the Wehnelt cap represents 25u and an error in distance of ± 15 u is tolerable.

Note: Proper Wehnelt to anode distance is 7mm ± 1 mm for 20 to 30 KV operation. Proper filament to outside surface of Wehnelt distance is 220u to 235u ± 15 u.

Operation of the Source

Once the LaB_6 has been centered in the aperture opening at the proper distance back, it may be installed in the emission chamber. Care must be exercised as rough handling of the gun

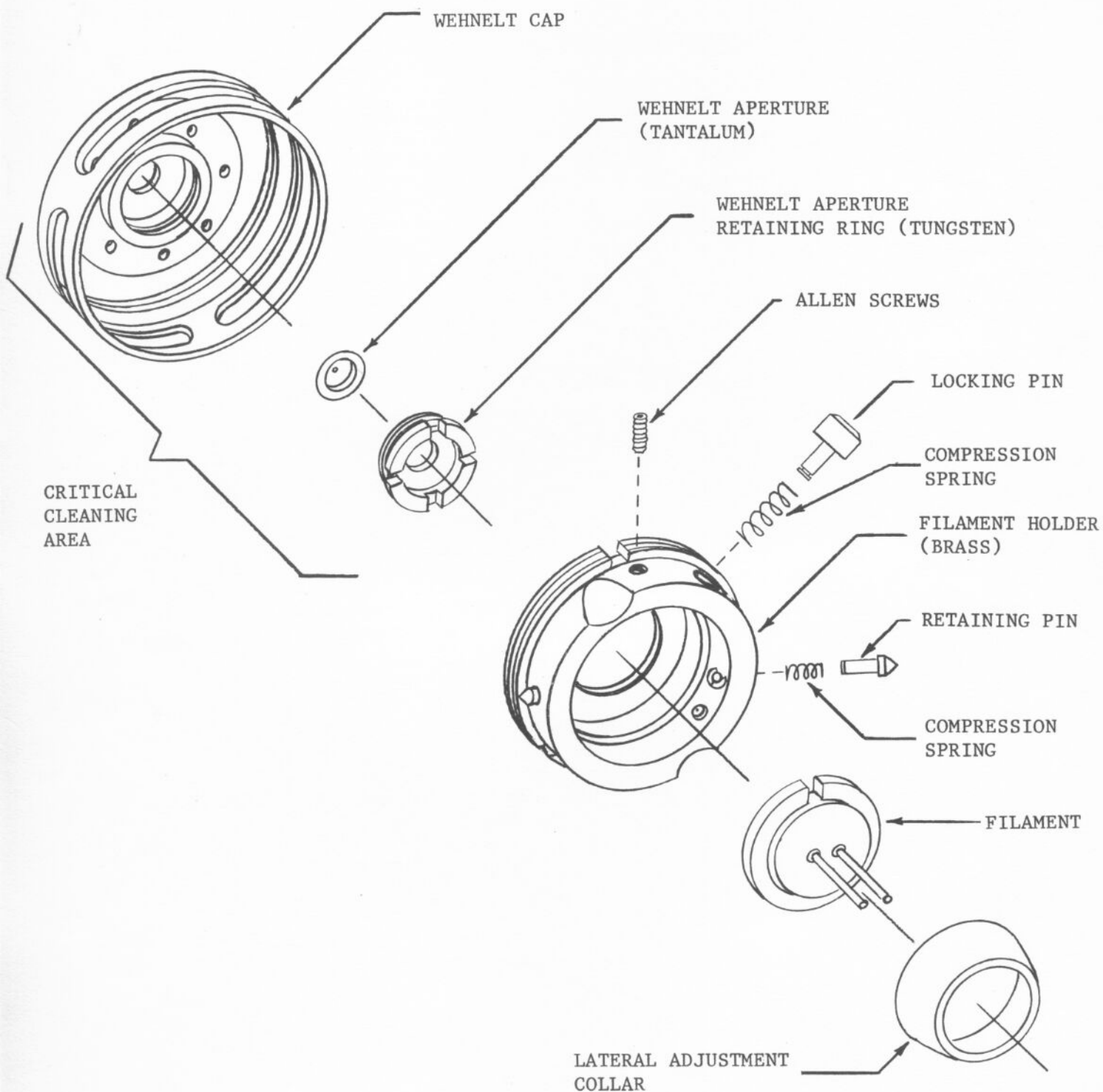


Figure 4.1A Tungsten Filament

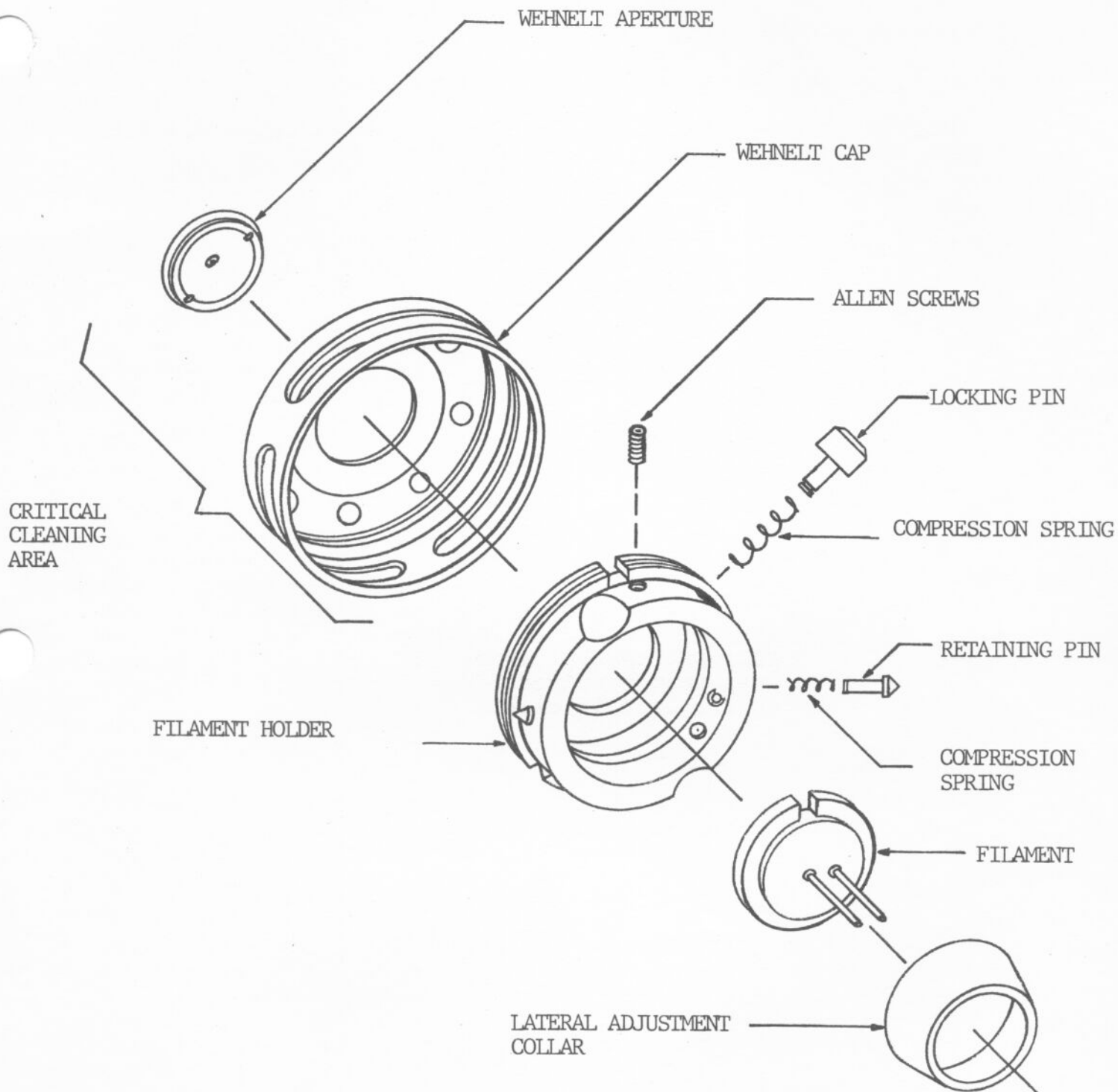


Fig. 4.1B LaB₆ Filament

OPTIONS AND ACCESSORIES

Operation of the Lanthanum Hexaboride (LaB₆) Assembly (Cont.)

cap, bending of the filament posts or a rough snapping of the gun onto the support may all cause breakage of the tip. The vacuum level in the emission chamber should be $2-3 \times 10^{-6}$ torr before any heat is applied, and ultimates in the 10^{-7} torr range should be attainable.

A. Heating the Source

Once required vacuum level is attained, KV may be applied to the gun. Proceed to 30KV in brief steps. A level of 30KV should be tried, prior to heating, to ensure that any arcing due to pieces of dirt, etc. will occur before heating. Initial heating is best done at 20KV, however, since degassing the tip may occur upon heating, which will cause minor arcing in the first 1/2 to 1 hour of use.

- B. Heating of the tip must proceed very slowly. Care should be taken such that heating up to the normal filament heat setting required for saturation of the LaB₆ source is of the order of 2-3 minutes. A suitable way to heat the filament is to turn the filament heating control up in about 10 equal steps, stopping about 10 to 20 seconds between each step. Do not turn filament control above the position of 1 major division less than required for saturation of a tungsten filament source at this time.

Alignment of the Source

The gun is mechanically aligned, in search for the brightest beam down the column, just as with a standard tungsten source. The beam alignment coils are also used during this search, with an attempt to keep them basically centered, although this is not always possible due to the nature of the source.

Unlike the standard tungsten filament, the LaB₆ source, although a single crystal, may be multilobed as evidenced⁶ by the multiple peaks which appear on the brightness meter, as the gun is mechanically rocked. It is generally necessary to explore the fine mechanical and electromagnetic rocking for each of the 2 to 3 peaks noted to determine which is the brightest source. This alignment will be very critical as the sources are much "sharper" than that of tungsten.

It will be necessary to maintain gun alignment for the brightest peak as the filament is slowly heated toward saturation.

Note: Utilize the bias voltage control to obtain normal emission currents at saturation (i.e. 80-120 for 20KV, etc.).

OPTIONS AND ACCESSORIES

Operation of the Lanthanum Hexaboride (LaB_6) Assembly (Cont.)

Saturation

The LaB_6 exhibits a saturation point which is not quite as sharp as that of tungsten. This means that some small increase of signal brightness or emission may be noted, even above the point at which it is desirable to operate. Saturation will occur at approximately 10% lower heating current than is necessary for the tungsten filament.

For those microscopes, where the filament control knob is calibrated with markings from 0 to 11, if the tungsten filament always saturates at 6, LaB_6 will saturate from 5.0 to 5.5. This saturation level may vary slightly from filament to filament, but does not appear to change during the life of the filament.

Saturation is reached when the brightness meter shows only a very small increase (less than 1 major division) when the filament heat is raised by only a fractionally small increase in the knob rotation (such as from 7.2 to 7.3 estimated). For this evaluation, the contrast meter should be almost full scale. If the signal drops on the brightness meter, a slight electromagnetic alignment adjustment will indicate whether or not a true increase has occurred (magnification 50-150X).

It should always be noted that the LaB_6 filament should be operated at the lowest heat setting number. If the filament runs stable after one hour, try to reduce the heat 1/10 of a division. If the filament continues to run stable, reduce the heat setting further until the lowest level has been obtained. Once the proper setting is established, it should be recorded in the log book.

It will require some time to become familiar with the operation of the LaB_6 . It is important to remember:

1. Not to overheat.
2. Carefully check both mechanical and electromagnetic alignment with each change in filament heat, KV or bias.
3. Proceed slowly and carefully.

Periodic Maintenance

Stability of gun emission should be reached within 1/2 hour on an already used filament and within an hour on a new filament. The filament should then run in a stable manner for some time.

OPTIONS AND ACCESSORIES

Operation of the Lanthanum Hexaboride (LaB₆) Assembly (Cont.)

On a new filament, although pre-baked, outgassing of contaminants may form a deposit on the anode or Wehnelt aperture within about 30 hours. This will be evidenced by a slight signal instability which will give changes in the brightness of the picture. If this occurs, it will be necessary to clean the Wehnelt aperture and anode at this time and to realign the filament.

Interlock

In order to avoid heating and cooling the filament each time a specimen exchange is made, it is desirable to keep the gun in operation during this exchange. For this, a vacuum electronics interlock has been established.

By closing the V₁ column isolation valve, the upper column and emission chamber becomes isolated from the lower column and specimen chamber. This permits dynamic pumping of the LaB₆ filament by the Ion pump during specimen exchange.

By maintaining proper alignment, adjustment, vacuum, and cleanliness, the LaB₆ source will provide long life, increased signal, and resolution. The use of gloves is highly recommended.

B. Digital Scan Generator

General Information

1. The 12-bit Digital Scan Generator consists of a PC card, a control board installed in the upper deck of the control panel, and interconnecting cables. The PC card is installed in the card slot normally provided for the Analog Scan Generator.
2. An internal crystal controlled clock, counters, and 12-bit digital to analog converters makes it possible to generate rates of various pitch density and scan rates. An LED display indicates the beam position for the X and Y in hexadecimal numbers. Panel operation is very simple and self-explanatory. Display and Record modes are compatible on the DSG.
3. The most popular feature of the digital scan generator is its use in conjunction with an external computer or instrument that will allow vector scans for several important applications such as electron beam exposure of various patterns on photoresist, automated x-ray analysis, automated image aligns, etc. For these applications AMRAY will advise users as required, however, the system hardware and software should be provided by the user.

OPTIONS AND ACCESSORIES

Condensed Specifications

1. Interchangeable plug-in PC card replaces standard Analog Scan Generator in system; may be exchanged in minutes.
2. Flexible computer-oriented digital interface to X-Y beam positioning circuits performs normal raster-scanning functions, also simplifies implementations of special beam control applications.
3. Control signals, input/output data, easily assessed through standard flat-cable connectors at the rear of instrument.
4. Dual high-speed 12 bit D to A converters locate raster co-ordinates to 4000 point precision in each axis.
5. TTL compatible input signals permit external control of clock rates, picture point density, parallel loading of random X-Y co-ordinates, vector scanning, etc.
6. TTL compatible output buffers enable continuous parallel readout of digital co-ordinates in real time or latching of single-point X-Y addresses by means of internally generated movable video crosshair display.
7. Latched addresses are displayed on front-panel hexadecimal alphanumeric LED indicators.
8. Typical applications:
 - pattern generation
 - image storage/enhancement
 - automated x-ray analysis
 - characterization of semiconductors
 - synchronous voltage contrast testing
 - spatial distribution data reduction
 - line scan profile comparison

OPTIONS AND ACCESSORIES

C. BSE/STEM/EBIC with Auxiliary Preamplifier

Introduction

The AMRAY Auxiliary Preamplifier System is an option available for all AMRAY SEMs. The preamplifier system is designed to accommodate several methods of electron beam imaging: solid state BSE, transmission, EBIC, and specimen current. The preamplifier system consists of one head amplifier box (for BSE, transmission and EBIC), whose outputs connect, via coaxial cables, to the inputs of the Auxiliary Preamplifier. The amplifier output may then be connected to any of the auxiliary video inputs on the SEM Control Console. The entire unit can be installed at the factory, or as a retrofit to existing SEMs in the field.

The Auxiliary Preamplifier is designed to mount either in the upper deck of the AMRAY 1000 series SEMs or as a stand alone unit for any of the microscopes. The head amplifiers are designed to mount on or near the chamber of all AMRAY instruments.

The total gain of the system is selectable at the auxiliary preamplifier. Gain ranges from 1000 to 500,000 when used in conjunction with any of the head amplifiers. For optimum response of the amplifier, it is best to use the lowest gain range possible.

Note: For a more complete description of this system with outline drawings, please see AMRAY Installation, Service and Operators Manual, Auxiliary Preamplifiers with Head Amplifiers for BSE/STEM/EBIC.

Operating Instructions

BSE Detection

1. Set up the sample specimen for typical SEM operation at 20-30KV, WD-11 to 15, 300u final aperture. The stage should be at zero degrees tilt.
2. Focus on the specimen in secondary mode.
3. Set the brightness and contrast meter levels both at zero on the SEM console. There is no need for use of these controls while using the Auxiliary Preamplifier.
4. Before selecting the video channel of the Auxiliary Preamplifier, set its coarse contrast to the "10" range and its fine contrast to the maximum (clockwise) position. The brightness control should be at mid-range.
5. The operating mode may now be selected. Channel A, B, A+B, or A-B in the Backscatter Mode.

OPTIONS AND ACCESSORIES

BSE/STEM/EBIC with Auxiliary Preamplifier (Cont.)

6. As additional contrast is required, the coarse contrast control can select higher ranges, "10" to "50", "50" to "100", etc. A sharp increase in contrast can be noticed on the contrast meter. Select the highest gain required and trim down using the fine contrast control. It is important that you use the lowest coarse range allowable to avoid saturation of the later gain ranges. This will lead to superior images.

Note: At higher gain ranges, a DC instability may be noted. This is due to the low frequency noise of the operational amplifier that is used (OP27EP) as first stage in the Head Amplifier. This amplifier is the best available at this time. To avoid this situation (usually only with relatively low contrast specimens) it is recommended to operate in the lower gain ranges 10, 50, 100 with respective reductions in spot size. The higher gain ranges are included in the amplifier for other applications where these gains are appropriate.

Transmission Detection

1. Prepare the sample using the Standard TEM techniques.
2. Insert prepared grid in grid holder.
3. Install circlip using injector tool provided to hold the specimen.
4. Mount the sample holder to the stage at 90° tilt. Place the stage in vacuum.
5. Operate SEM in secondary mode (20-30KV, 100-200u final aperture, short W.D.) to locate the sample holder.
6. Refer to "BSE DETECTION" steps 3 thru 4, 6, for further operation.

EBIC

1. Prepare the desired sample using standard EBIC techniques. The connection from the sample to the amplifier BNC's should be made inside the chamber via a Winchester connector. This allows up to four connections to the sample. If two areas are of interest simultaneously, proper connection can be made and performed on BSE channel A+B. Simply connect one device across inputs A and B, and the second device across C and D inputs. The video chain of BSE A+B should now be followed.

OPTIONS AND ACCESSORIES

BSE/STEM/EBIC with Auxiliary Preamplifiers (Cont.)

In general, the device is not grounded to the specimen stage. Rather, the ground reference point of the sample is brought out to the head amp via the Winchester Connector and appropriate BNC's.

Note: It is recommended that the user set up any sample that can be understood easily to assure that EBIC is working correctly.

2. Follow steps 2 through 4,6 for BSE Detection.

D. Electrostatic Beam Blanking

Introduction

1. The nanosecond electron beam blanker housing is permanently installed as a one inch high section below the emission chamber on the SEM column. The active blanker assembly may be removed from the column when not in use and a vacuum plug installed in its place.
2. The active blanker assembly consists of a rod onto which two electrostatic plates 5mm thick are mounted. One of the plates is mounted to the rod directly and is thereby grounded. The other plate is isolated from the rod by a ceramic insulator. The plate is connected to a high vacuum compatible BNC coaxial feedthrough. The plates are spaced by 1mm and the spacing centered on the electron optical axis. A small external amplifier providing pulses of about 20 volt amplitude is connected to the BNC connector.

24 volt power to the amplifier is derived from the SEM power supplies. TTL compatible pulses (0 volt to +5 volt) control the electron beam (0 volt beam on and +5 volt beam off). The control pulses are generally derived from customer provided test equipment.

Operating Instructions

1. To inspect beam blanker, shut off beam source, close column isolation valve and admit air to the upper column as is done to change the electron source.
2. Remove plug in beam blanker support.
3. Inspect and clean beam blanker assembly if required and measure with an ohm meter to assure that the active plate is isolated from the rod and connected to the BNC connector, check O-ring and seat.

OPTIONS AND ACCESSORIES

Electrostatic Beam Blanking (Cont.)

4. Insert blanker unit into housing and assure that it is fully seated in the seal position. The retensional position is guided by the pin-slot arrangement. Insert shorting plug to the beam blanker.
5. Pre-pump column.
6. Obtain standard image on SEM Display.
7. Connect blanking amplifier cables and TTL compatible generator.
8. Vary frequency of generator to observe if scanned beam is being blanked.
9. On/off performance of the beam blanker image may be observed at very low frequencies by using a picoampere meter connected to a preamplifier or observed on a display tube in the line scan mode where the off position may be determined and marked on the screen when the filament heat is turned off.
10. The beam alignment controls may be used to obtain optimum ON-OFF performance of the beam.

Maintenance

Periodic cleaning of the beam blanking plates is required and is dependent on use*. With use, the plates become contaminated and must be cleaned by procedures that are similar to anode cleaning. The assembly is removed from the column as described above and disassembled.

- * If beam drift occurs, or contamination is manifested by brightness variations, cleaning must be undertaken.

Picosecond Electron Beam Blanker

Operating Instructions

1. Unit must be properly installed and tested according to installation procedures.
2. Initially, the beam blanking aperture is fully withdrawn from the beam axis, and the beam blanker deflection plates are separated by more than 4mm for unimpeded beam passage.

OPTIONS AND ACCESSORIES

Electrostatic Beam Blanking (Cont.)

3. The SEM is operated at the desired beam energy and all column parameters are optimized before the beam blanker is adjusted.
4. Set SEM image at about 100X magnification. Do not apply any voltage or pulse to the beam blanker.
5. Insert beam blanker aperture by rocking the aperture rod sideways as it is advanced along its axis. The V-notch located on the tip of the aperture holder will guide the operator to the center of the rod when the base of the V-notch is detected. From that point, only an axial adjustment should be required to find and center the first aperture; i.e. the image is evenly illuminated at low magnification.
6. Move the left deflection plate (grounded) toward the beam axis by turning front micrometer counter-clockwise until the image illumination is reduced. Turn micrometer slightly clockwise until image is fully restored.
7. Move the right deflection plate (50 ohm terminated) toward the beam axis by turning rear micrometer clockwise until the image illumination is reduced. Turn rear micrometer counter-clockwise until the image is again fully restored. Both deflection plates are now centered around the electron beam at a minimum distance of roughly 700 micrometer spacing.
8. The operator should note and record readings on both micrometers for future reference.
9. Depending on the blanking voltage available and the ultimate operating speed, the blanking plates can operate over a wide range of spacings; for example, 1 volt pulse at 700 micrometer plate spacing can blank a 10KV beam fully.
10. Connect coaxial cable of beam blanker to pulse generator or pulse amplifier output with 50 ohm source impedance. Either pulse or polarity can be used. If the generator has an output amplitude adjustment, set the amplitude to about 1 volt.
11. As the image is scanned at a slow scan rate, set the pulse generator to 1-5 cycles per second and increase the blanking pulse amplitude until banding is observed on the display tube. The black bands represent intervals during which the electron beam is blanked.

OPTIONS AND ACCESSORIES

Electrostatic Beam Blanking (Cont.)

12. For precise setting of pulse amplitude and plate spacing, run SEM in the line scan mode. By temporarily shutting off beam with the beam alignment controls, determine the line scan's lowest vertical position on the display and mark the position with a felt tip pen. This same level must be achieved with a blanked beam.
13. Return beam alignment potentiometer to previous beam on position and initiate blanking at a frequency low enough for the line scan rate to follow.
14. Adjust the pulse amplitude to obtain a full excursion of the pulses observed in line scan. The bottom of the pulse must be on same level as determined in 12 above.
15. The user should understand that pulse amplitude and plate spacing are related. The larger the spacing of the plates, the more pulse amplitude is required to obtain effective blanking. Similarly, for very high frequency operation, it is very advantageous to require a low amplitude pulse. In those cases, the plate spacing must be small to obtain effective beam blanking.
16. It must also be understood that the use of very small plate spacings will result in faster contamination of the plates.
17. For each application there is an optimum pulse height and plate spacing combination that must be learned.
18. With proper adjustments, ON/OFF beam current ratios of 10,000:1 (80 db) have been obtained at 1 to 2KV beam energies. The beam blanker can be employed for any frequency of blanking pulses from DC to 2 GHz, and at any duty cycle within that frequency range. 200 pico sec. rise and fall times have been observed in conjunction with proper pulse generators.
19. If the beam blanker is not in use, it is advantageous to operate the SEM with the beam blanking plates about seven mm apart. For that setting, the micrometer should be set to the following readings:

Front micrometer to zero
Rear micrometer to .300 inches

Similarly, the beam blanker aperture rod should be retracted fully to the end of the axial hand screw. In this manner, the components are out of the beam and therefore will not be contaminated.

OPTIONS AND ACCESSORIES

Electrostatic Beam Blanking (Cont.)

It is very important that the anode aperture (300 micrometer) is always inserted, otherwise the beam blanker is exposed to gun radiation about 10mm in diameter, which will lead to beam blanker contamination even in its withdrawn position.

Beam Blanker Maintenance

Maintenance of the Beam Blanker should be restricted to the cleaning of the aperture rod and apertures, and to aperture replacement. Depending upon the amount of use, the deflection plates should be removed and cleaned by methods identical to that for the aperture rods.

Aperture Rod Cleaning

1. Admit air to the beam blanking cavity.

Note: On instruments with column valves located below the beam blanker, LaB₆ source must be turned off, and air must be admitted to the emission chamber section.

On instruments with column valves located above the beam blanker, air is admitted to it at the same time the specimen chamber is vented.

2. Remove beam blanking aperture rod and clean thoroughly.
3. Insert either cleaned or new platinum apertures:
1st aperture - 200 micrometer hole
2nd aperture - 100 micrometer hole
4. Remount aperture rod, evacuate system and proceed as described in the Operating Section.

Removal of Column Liner from Column

To remove column liner from column for general maintenance, the aperture and the beam blanker assembly must be removed from the beam blanker cavity as described in Aperture Rod Cleaning (see above) and Deflection Plate Cleaning (see below).

Deflection Plate Cleaning

1. Admit air to the beam blanking cavity.
2. Remove the four Allen screws and pull the blanker assembly from its cavity.

OPTIONS AND ACCESSORIES

Electrostatic Beam Blanking (Cont.)

3. Loosen set screws and remove connecting wires.
4. Turn beam blanker upside down. With the correct Allen wrench and a screwdriver, unscrew deflection plate mounting screws, located through the two 10mm diameter holes in the aluminum base.
5. After thorough cleaning and rinsing, the plates are replaced again and must be aligned visually to be perfectly parallel on the active surfaces.
6. The plate with the 4-40 set screws on the side mounts to the insulator plate. The plate with 2-56 set screws mounts to the grounded side.
7. Replace the connecting wires and make sure that the resistor is properly installed and that the plates can be driven from .7mm to 7mm spacing without excessive pull on resistor wires.
8. Before inserting the column, check with ohmmeter for 50 ohms to ground at coax connector.
9. Reinsert into column cavity (check O-ring and surfaces) and fasten with 4 screws.
10. Re-pump and proceed as in Operating Instructions.

E. Five Axes Motorized Stage

1. AMRAY's Five Axis Motorized Specimen Stage provides the following motions and ranges with a multi-position control Joystick and digital LED readout.

<u>Motion</u>	<u>Range</u>	<u>Type</u>
X	125 mm	Step Motor
Y	125 mm	Step Motor
Z	40 mm	DC Motor
Rotation	360° continuous ($\pm 250^\circ$)	DC Motor
Tilt	$\pm 90^\circ$	DC Motor

2. Sense of Motion

The stage is arranged within the specimen chamber such that tilt motion is either towards the left (-), or right (+), side of the chamber from the standpoint of the operator facing the front of the specimen chamber. The front of the chamber is the port opening that accepts entrance and withdrawal of the stage.

OPTIONS AND ACCESSORIES

Five Axes Motorized Stage (Cont.)

In this configuration, the ET electron detector is located on the right side of the chamber and the tilt axis is therefore along an axis perpendicular to the front of the chamber. The scan coils must be mechanically rotated such that their X and Y sense aligns with the X and Y sense of the stage motion (at 12mm W.D.).

<u>Stage Drive</u>	<u>Sense of Motion</u>
Positive X	Joystick Right, area of interest moves toward stage door.
Negative X	Joystick Left, area of interest moves toward back of chamber.
Positive Y	Joystick Up, area of interest moves toward detector.
Negative Y	Joystick Down, area of interest moves away from detector.

Note: X=0, Y=0 is defined at center of stage X, Y motion and positive and negative values are indicated by corresponding + and - notations on the LED readout.

Positive Z	Joystick Down, sample moves up, W.D. shorter.
Negative Z	Joystick Up, sample moves down, W.D. longer.
Positive Rotation	Joystick Right, sample rotates clockwise.
Negative Rotation	Joystick Left, sample rotates counterclockwise.
Positive Tilt	Joystick Up, sample tilts toward detector.
Negative Tilt	Joystick Down, sample tilts away from detector.

3. Apparent Motions on CRT (12mm W.D.)

<u>Motions</u>	<u>Appearance on CRT</u>
X	Horizontal; Positive toward right, toward stage front.

OPTIONS AND ACCESSORIES

Five Axes Motorized Stage (Cont.)

<u>Motions</u>	<u>Appearance on CRT</u>
Y	Vertical; Positive up, toward detector.
Z	Focus Change; Positive requires clockwise change of focus controls.
Rotation	Rotation; Positive clockwise.
Tilt	Tilt axis horizontal on CRT.

Note: Above 5,000X, mechanical X, Y motion of stage is deactivated and the beam itself is digitally moved via the Joystick lever, utilizing electrical scan shift. Scan coil controls on front panel and mechanical coil rotation must be oriented to maintain same sense of X, Y motion as observed below 4900X (mechanical motion). Scan shift is deactivated by proceeding below 4900X. Manual scan shift controls on SEM panel are used as in normal SEM operation.

4. Absolute Stage Location

The Z, rotation, and tilt conditions of the stage are sensed by an analog potentiometer geared to each motion and are converted to digital LED display by the microprocessor stage control. Therefore, these conditions are remembered even if the stage controller is electrically deactivated (see calibration procedure).

However, if the power is shut off, the X and Y coordinates of the stage are not remembered. This is due to the fact that the system counts steps of the stepping motor relative to an initial power up condition only.

In addition, the stage should be inserted and removed from the chamber only in the load/unload position, especially in the case of large samples, to avoid damage to sample, lens, stage, or detector. (See Operation "Load Position").

If the stage is driven to the load position at the end of the day (automatically when load button is pressed) X and Y will be at 0, 0. The motor controller can then be turned off and X=0, Y=0 will be retained properly when the controller is again activated.

OPTIONS AND ACCESSORIES

Five Axes Motorized Stage (Cont.)

Resetting X=0, Y=0

If the stage power is accidentally lost when the stage is not at X=0, Y=0, its coordinates may easily be reset by the following procedure.

- a. If the stage is in the specimen chamber, carefully drive stage to some position where it can be removed with no damage (lowest Z, tilt 0°, X, Y roughly centered).
- b. Access stage and insert small specimen stub (such as AMRAY standard) with top of stub approximately on tilt axis, tilt to 0°, X, Y centered by eye.
- c. Insert stage and pump down.
- d. Obtain image at WD = 12mm, tilt = 0°, lowest magnification possible.
- e. Using rotation control, identify center of rotation and use X, Y controls to drive this point to center of screen. Proceed to higher and higher magnification until center of rotation is at center of CRT at 200-800X.
- f. Turn off motor controller. Wait 3 seconds, turn on motor controller. Disregard alarm. Stage is now at absolute X=0, Y=0 within 0.01 to 0.1mm (LED readouts X=0, Y=0).

5. Anti-Backlash Control/Return to Origin

The anti-backlash control performs an automatic X, Y loop of 50 - one-micron steps negative and then 50 - one-micron steps positive, to remove stage backlash if absolute coordinates are to be remembered or returned to.

Note: Z, Rotation, Tilt settings are not returned in the automatic sequence of the manually controlled joystick stage and must be noted by operator if changed during sample searching.

Scan shift X, Y motions attained by operation of X, Y Joystick above 5,000X are only remembered and incorporated in area relocation if the magnification does not go below 50X. If the magnification is set below 50X control, Joystick attained scan shift X, Y offsets are returned to zero and relocated area may shift on CRT by up to 50 to 100 microns.

OPTIONS AND ACCESSORIES

Five Axes Motorized Stage (Cont.)

With the Joystick controlled stage, one arbitrary position of X, Y may be remembered and returned to (Set Origin, Return to Origin) within a precision of about 5u. There are two ways to reproducibly locate and return to some pre-selected location.

5.1 Without Electrical Scan Shift

In this mode, the magnification control can proceed below 50X since Joystick attained X, Y scan shift is not utilized in precisely positioning an area of interest.

- a. First, proceed below 50X to reset any remembered Joystick attained scan shift.
- b. Locate and identify an area of interest at any magnification up to 4900X. Do not proceed higher than 4900X.
- c. Activate backlash control. Area of interest will probably shift due to elimination of backlash.
- d. Reposition area of interest, trying to utilize positive stage direction of motion of more than 100u with X and Y drives (right, up) as a finishing motion.
- e. Repeat with intermediate Anti-Backlash loops until area of interest remains centered at desired magnification below 4900X. Manual scan shift may be used, but should not be disturbed after point of interest is finally positioned.
- f. Activate Set Origin or record X,Y locations.
- g. Area of interest will then be recovered to about 5u if exact coordinates are returned to and Anti Backlash control is activated as a final step. (Return to Origin may be used). Manual scan shift should not be disturbed.

Note: Z, Rotation, Tilt are not recalled automatically. If these are utilized, area relocation will not occur.

5.2 With Electrical Scan Shift

- a. Locate and identify an area of interest at any magnification.

OPTIONS AND ACCESSORIES

Five Axes Motorized Stage (Cont.)

- b. Activate Anti-Backlash control. Area of interest will probably shift due to elimination of backlash.
- c. Reposition area of interest as in 5.1 d above, and finalize positioning above 5,000X. Finish with final Anti-Backlash loop. Some X, Y scan shift is now incorporated in location.
- d. Activate Set Origin or record X,Y location.
- e. Do not follow with any magnification setting below 50X, and use no further X,Y drive above 4900X, otherwise incorporated scan shift X,Y offsets will be disturbed.
- f. As in "g" above (see step "g" under preceding section).

SECTION FIVE

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

A. Recommended Cleaning Procedures

Routine Cleaning Procedures

Some components of the electron optical column will be "contaminated" with dark stains at varying degrees of intensity. Other areas will appear relatively clean. Any surface which comes in contact with the electron beam will probably require a variety of cleaning and polishing materials and procedures to remove the contamination.

Cleaning Frequency

How often the instrument needs cleaning depends on a number of factors and conditions. These include hours of use, type of samples, accelerating potential and beam current. Observe the following guidelines:

1. With every filament change, the Wehnelt cap, Wehnelt aperture, aperture retaining ring, should be cleaned, along with the anode and anode cap.
2. The final aperture holder should be at least cleaned when there is contamination evident when visually inspected.
3. The column liner and detector assembly need the least amount of attention by the user. If the above areas have been thoroughly cleaned and there is still evidence of contamination or astigmatism, then and only then should these assemblies be removed and cleaned.

Areas to be Cleaned

After determination that the instrument is showing signs of signal loss or astigmatism, some decision must be made as to where the contamination lies in the electron column. This depends on the type of vacuum pumping station in the particular instrument. A 70/20/10 rule is suggested:

1. Models with Vac-Ion Pumped Emission Chamber

-70% of the time when contamination is evident, the final part which needs cleaning will be in the Final Aperture Area.

-20% of the time the part(s) which need cleaning will be in the Electron Gun Area.

-10% of the time, cleaning will need to be done in the Column Liner Detector or the Polepiece area.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Recommended Cleaning Procedures (Cont.)

2. Models without Vac-Ion Pumped Emission Chamber

- 70% Electron Gun Area
- 20% Final Aperture Area
- 10% Other

Cleaning Methods

1. A metal polish with a small amount of abrasive and slight chemical action may be used (typical commercial products are POL or Metalputz), along with lint-free cloths (Texwipes).
2. Wooden sticks are very helpful in cleaning small hard-to-get-to areas. Cotton is not to be used near threaded parts because loose fibers are difficult to remove.
3. Remove excess polish and rinse and scrub in household liquid detergent (1 part liquid detergent, 1 part water). *MR. CLEAN preferred, or SIMPLE GREEN.*
4. Rinse away soap residue with hot water.
5. Flush parts with alcohol.
6. Blow dry with Dust-Off or Clean lab air.
7. Set parts aside on a clean lint-free cloth and cover. Do not handle with fingers after cleaning.

Hints on Cleaning

1. DO take special care when polishing parts. The instrument can never be too clean.
2. DO use a strong solution of household liquid detergent. It is more effective when used full or half strength.
3. DO remove all soap stains. If a stain exists after initial drying, simply re-rinse the part in hot water.
4. DO break wooden sticks to custom make cleaning tools. Remember to use the same type of tool when detergent rinsing that was used to polish.
5. DO use an ultrasonic cleaner if available; 3-4 minutes in an ultrasonic bath is adequate.
6. DO NOT use other types of abrasive cleaners unless absolutely necessary.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Recommended Cleaning Procedures (Cont.)

7. DO NOT handle clean parts with bare hands. Use lint-free cloths or gloves when re-assembling.

B. Removal and Assembly of Cleaned Parts

1. Electron Gun - See filament replacement section (Page 106).
2. Anode Assembly - Vac-Ion Pumped

Clean anode

1. pol polish

2. Mr Clean

3. H₂O (hot) CAUTION

4. freeon If instrument was running, gun parts are hot.

5. blow dry 3. Unscrew the threaded anode support/adjuster.

4. Remove the anode by unscrewing it from the anode adjuster.

5. Remove the anode cap from the anode, being careful not to lose the 300u aperture seated at the bottom of the cap.

6. Tap out aperture on a glass slide or lens tissue. Refer to aperture cleaning section, page 100.

7. Re-assemble all cleaned anode parts by reversing this procedure. Restore height of anode adjuster.

Note: All apertures should be shiny side towards electron beam

C. Removal and Replacement of Anode

1. Remove anode adjuster with anode and cap in place.

2. Remove anode and cap from adjuster.

3. Remove the cap from the anode being careful not to lose the 300u aperture seated at the bottom of the cap.

4. Tap out the aperture on a glass slide or lens tissue. Refer to aperture cleaning section.

5. Reassembly all cleaned parts by reversing this procedure.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

D. Aperture Cleaning Methods

All platinum apertures should be cleaned by FLAMING with a PROPANE Gas Torch. AMRAY does not recommend natural or laboratory gas for flaming apertures. Laboratory gas generally contains many impurities which accumulate on the apertures and cause contamination and stigmatism in the SEM.

The apertures should be handled carefully from the sides, using clean forceps only. Avoid scratching the surface of the aperture with the forceps.

1. Remove the apertures from the instrument. (Refer to Removing and Cleaning the Final Apertures and Removing and Cleaning the Column Liner.
2. Place the aperture (only one at a time) in a platinum aperture flaming tool. Clean only one aperture at a time.
3. Heat the aperture to CHERRY RED in color for one to two seconds, using the propane torch. Do not heat to WHITE in color. This intense heat may destroy the symmetry of the aperture. If the aperture cannot be cleaned by heating to the cherry red state, replace it with a new aperture. Also note that if the aperture appears to have "alligator skin" (grains that are apparent on the surface), discard the aperture and replace it with a new one.

E. Removing and Cleaning of the Adjustable Final Apertures

Periodically, the final (adjustable) apertures must be removed from the column and cleaned. The frequency of cleaning will vary, depending upon the amount of use of the instrument, the type of samples used, etc. Increased astigmatism is one of the first and best indications of a dirty aperture.

Remove the adjustable (final) apertures according to the following procedure:

1. Vent the specimen chamber by depressing the "Chamber Vent" button.
2. When the chamber has reached atmospheric pressure, pull the Aperture Retainer Pin up and out of the Aperture Housing. The Aperture Housing is spring loaded and will be pushed away from the column.
3. Remove the Aperture Housing and note that the end of the aperture holder is now visible.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Removing and Cleaning of the Adjustable Final Apertures (Cont.)

4. Remove the Aperture Holder from the chamber.
5. Use fine forceps to remove the spring and Retaining Pin which holds the three apertures in place.
6. Remove the three apertures by tilting the holder and tapping the apertures onto a glass slide or lens tissue.
7. Clean apertures according to the procedure on page 100. Usually the aperture holder itself will require cleaning. Clean the holder as with the other column parts.
8. Replace the apertures (usually with the 300 um aperture first, then the 200 um aperture, followed by the 100 um aperture) and make certain that the flat side of the aperture is facing downward when inserted in the holder. The flat surface of the aperture will then face the electron beam.

NOTE: Apertures are to be considered consumable items. If there is any question as to the aperture's usefulness, throw it away.

9. Replace the Spring and Retaining Pin and insert the aperture holder into the column. Be certain that the three holes in the holder are facing the electron beam (facing upwards).
10. Replace the Aperture Housing and the Housing Retainer Pin.
11. Depress Chamber Vent and wait for Hi-Vac operation.
12. Obtain an image.
13. Align the Aperture.

F. Removing and Cleaning the Column Liner

You will need the nylon Column Liner Cleaning Rod and the Metal Column Liner Removal Tool for this procedure.

1. Vent the entire column.
2. When the column has reached atmospheric pressure, lift off the Gun Assembly.
3. Remove the Anode, using lint-free gloves.
4. Place the two (2) pins of the Column Liner Removal Tool into the two (2) small slots on the top of the column liner.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES (Cont.)

Removing and Cleaning the Column Liner (Cont.)

5. Rotate the column liner so that the large slot is aligned with the metal clip on the column (i.e. released from the clip).
6. Screw the "threaded end" of the metal removal tool into the threaded hole in the top of the column liner.
7. Slowly pull straight up on the metal tool and lift the column liner from the column of the SEM. The column liner fits snugly, so do not hesitate to pull firmly.
8. Unscrew the metal tool from the column liner.

NOTE: Inside the column liner is the Column Liner Aperture Assembly. It must be removed prior to cleaning the column liner.
9. Remove the Column Liner Aperture Assembly by unscrewing, using the assembly removal tool.
10. Unscrew the Aperture Cap and turn the assembly upside down to drop the aperture onto a glass slide or lens paper.
11. Clean the aperture according to the instructions on page 100.
12. Use Metalputz or POL polish, a toothpick and a split of wood to clean the assembly. Clean according to the procedure for cleaning other column parts.
13. Insert the nylon cleaning rod into and through the column liner tube from the top.
14. Thread a small piece of lint-free cloth into the end of the cleaning rod.
15. Place the polish on the lint-free cloth, then pull the cleaning rod through the column liner to coat the inner surface with the polish. Push the rod in and out many times to coat the surface with the polish and to clean.
16. Discard the piece of lint-free cloth with the polish, then re-insert the cleaning rod through the column liner.
17. Thread a piece of lint-free cloth into the end of the cleaning rod.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES (Cont.)

Removing and Cleaning the Column Liner (Cont.)

18. Place the clean lint-free cloth and the end of the column liner in a beaker containing warm water and liquid household detergent (about 1 part detergent to 1 part hot water). Pull the cleaning rod up through the column liner. This creates a siphoning action which will wash the inner surface of the column liner. Pump the soapy water through the column liner ten or fifteen times or more.
19. Remove the cleaning rod and run hot water through the liner to remove the soap.
20. Squirt alcohol (100% ethanol, denatured is satisfactory) from a squeeze bottle down the column liner to remove the water.
21. Dry by blowing clean gas (air, dry nitrogen, or freon) through the column liner. AMRAY does not recommend the use of compressed, in-house laboratory gas because of the impurities which can accumulate on the surface of the column liner and cause contamination.

G. Reassembly of the Column Liner Aperture

AMRAY recommends the use of lint-free cloth or lint-free gloves for handling the parts once they have been cleaned.

NOTE: Before reassembling the aperture assembly and replacing the column liner, double check the parts for cleanliness. There should be no residual organic material or debris from the cleaning procedure. Handle apertures with clean tweezers only.

1. Place the 300um aperture in the aperture cap. The flat surface of the aperture should face upwards when installed in the liner. Screw on the aperture cap.

H. Inserting the Aperture Assembly into the Column Liner

When following this procedure, the points below should be noted.

1. The assembly is inserted from the base of the column liner.
2. The Aperture Cap is inserted first.
3. Screw aperture assembly into liner until it stops.
4. Replace the column liner into the column of the SEM. As you approach the seated position, align the large slot of the

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Inserting the Aperture Assembly into the Column Liner (Cont.)

liner with the metal clip of the column of the SEM. Push the liner down until it is firmly in position. Place the two pins of the metal tool into the two small slots on top of the liner and turn the liner approximately one fourth ($\frac{1}{4}$) turn counterclockwise until the metal tool hits the clip.

5. Replace the anode and gun assembly. (Check gun O-ring beforehand for dust).
6. Re-pump the entire column. When the proper vacuum is reached, proceed to normal operation of the SEM.

NOTE: The use of clean, dry ethanol is recommended whenever continued or prolonged exposure is likely. Methanol and Isopropanol are poisonous when inhaled, ingested or absorbed through the skin. However, to reduce costs, denatured 100% ethanol may be used.

I. Scintillator Replacement

The 1610/1645 electron detector consists of three major components that will require periodic maintenance. These are the scintillator disk itself, the scintillator retaining ring and the collector screen. When specimens de-gas or deteriorate under electron beam bombardment, discharges in the detector may be observed. These have been described as "pulse flashes" or "speckles" during raster display. Sometimes these discharges may be present even if the electron beam is off while at normal operating contrast levels. These periodic flashes should not be confused with statistical "noise" due to low signal levels or photomultiplier noise due to high contrast settings.

Scintillator maintenance needs attention when signal level, signal quality or reduced resolution is evident. Should the scintillator need replacing, the following procedure is recommended.

1. Vent the specimen chamber.
2. Swing the stage door out of the specimen chamber.
3. Remove the collector screen by sliding it forward towards the stage door opening.
4. Remove the scintillator ring by pulling straight forward as with the collector screen. The disc will probably come out together with the retainer ring.

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Scintillator Replacement (Cont.)

5. Clean the collector screen and retaining ring.
6. Handle new discs only at the edges. Insert the new disc into the ring with the coated surface facing toward the front door. Be extremely careful not to scratch the coated side of the disc.
7. Place the ring with the disc onto the copper sleeve at the end of the light pipe. Slide on firmly by touching only the retaining ring. Do not rotate the ring when inserting. Seat properly.
8. Re-install collector screen, making sure the small brass clip is on the outside of the base of the screen and is making firm contact with the screen. Do not reshape the collector screen. Electron collection efficiency is best when the screen maintains its original form.

NOTE: Periodically the light pipe and copper sleeve may be wiped off with alcohol. Do not attempt to clean the scintillator disc.

J. O-Ring Maintenance

"O" Rings on the final aperture holder, the stage door and emission chamber should be cleaned when exposed to atmosphere during disassembly.

The stage door O-ring needs no grease and only needs inspection when the chamber door is open. If small lint or dust particles are present, simply wipe an alcohol wetted, lint-free cloth over the entire O-ring to remove debris.

The final aperture O-ring will probably require a small amount of silicone vacuum grease. Wipe off excess grease and use the smallest possible amount.

K. Vibration Isolation

The electron optical column must be isolated from the cabinet using the "air bags". In addition, the incoming roughing vacuum hose must clear the sides of the hole provided in the console and electrical cables must be free to move. All cables must be free to move.

Periodically check to see that the column is "floating" freely on its vibration isolation mounts. If the column is not floating freely, use the pump provided to inflate the air bags. The bags

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ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Vibration Isolation (Cont.)

are accessible by removing the console covers. The column should be level and the console convenience table (formica) should not touch the column.

L. Vacuum Maintenance

The mechanical pump and turbo pump require regular lubrication. For further detail, see the manufacturer's manual. The AMRAY Service Department will change the oil in the mechanical pump and re-grease the turbo pump on a scheduled routine basis during all warranty and contract periods.

M. Tungsten Filament Replacement and Gun Alignment

Note: Also see Section 4-A, 3-M, concerning LaB₆ gun.

Tungsten filament life will vary, depending upon proper emission saturation, careful filament heating, gun vacuum and emission current. However, lifetime will generally lie in the range of 20 to 40 hours. If the filament burns out during operation, the signal will be lost on the viewing CRT, the emission current will drop to zero, and the filament burnout light will be illuminated.

1. Turn down filament current and shut off high voltage.

2. Close the column isolation valve. (✓).

3. Ion pump power off if present.

4. Vent gun chamber. turn gun isolation valve ^{Hit Vent} yes, ~~change~~

NOTE: It is highly recommended to backfill (leak to atmosphere) with dry nitrogen.

WARNING: Electron gun will be extremely hot.

CAUTION: Handle gun components with gloves or lint-free cloth only.

5. Lift off the gun assembly at "O" ring and set down on a convenient surface. Pull off the Wehnelt assembly by grasping the end piece (Wehnelt cap) firmly and pull straight back. Do not twist.

6. Unscrew the bronze filament holder from the wehnelt cap exposing the filament and lateral adjustment collar.

7. Loosen the allen screws and remove the collar and filament.

8. Unscrew the Wehnelt aperture, retaining ring, and 500u Wehnelt aperture.

START UP:

- ① Butterfly valve OPEN.
- ② V_1 closed.
- ③ Turn Vacuum Power ON.
 - if Vent light goes on, push to obtain vacuum.
- ④ Let pump 10-15 minutes.

Still Open:

- ⑤ Turn Ion Pump Power ON.
- ⑥ Press Start. (to go ON.)
- ⑦ If Reset light goes on, press to turn off.
- ⑧ Ion Pump to 200 MA.
 - as long as current needle keeps decreasing, let keep pumping. If not, turn Ion Pump Power off, wait, try again in 5 min.
- ⑨ Let go to 20 MA, close butterfly valve.
- ⑩ 10 MA → Push Start. (Project ^{mode} goes off.)
- ⑪ Run at 1-2 MA.

Clean Wehnelt Cap, Retaining Ring

1. Pol Polish

2. Mr Clean

3. H₂O ROUTINE MAINTENANCE AND SERVICE PROCEDURES

4. Tungsten Filament and Gun Alignment (Cont.)

5. How dry

Wehnelt Aperture (Only Ta aperture!!!)

1. Comet 2. Pol Polish

3. Mr. Clean 4. H₂O 5. freon 6. blow dry

9. Carefully clean the Wehnelt cap, Wehnelt aperture, Wehnelt aperture retaining ring and lateral adjustment collar.

(or Brass?) 10. The bronze filament holder need not be polished every time a filament is replaced.

11. Gun is now ready for re-assembly and alignment.

12. Install Wehnelt aperture and tighten with the retaining ring.

13. Screw the filament holder into the cap. Using the thumb and middle finger until the holder stops. Utilization of a wooden stick placed behind the spring-loaded locking pin will make the assembly somewhat easier.

14. Back off the filament holder 2½ full turns (this assures the filament will not be damaged when inserted).

15. Carefully insert the new tungsten filament into the holder, making certain the notch in the ceramic base lines up with the pin in the filament holder.

16. Place the lateral adjustment collar over the base of the filament.

17. Center the collar by using the three allen screws and tighten.

18. Turn the assembly over so the Wehnelt aperture is facing up. The filament tip should be in view looking through the Wehnelt aperture. If not, re-center the collar as in the previous step.

NOTE: Centering of the filament can be (easily) accomplished with the use of a low power light microscope.

19. Center the filament using the 3 allen screws. This is done by a combination of loosening and tightening the three allen screws.

20. Tilt the Wehnelt assembly sideways and turn the filament holder in (clockwise) until the filament tip is flush with the top surface of the Wehnelt aperture.

21. When the assembly is flush, rotate the filament holder counterclockwise 5½ divisions on the Wehnelt cap. This will withdraw the filament to the approximate proper distance from the outside face of the Wehnelt aperture. Optimum operating distance is 125 to 137 microns.

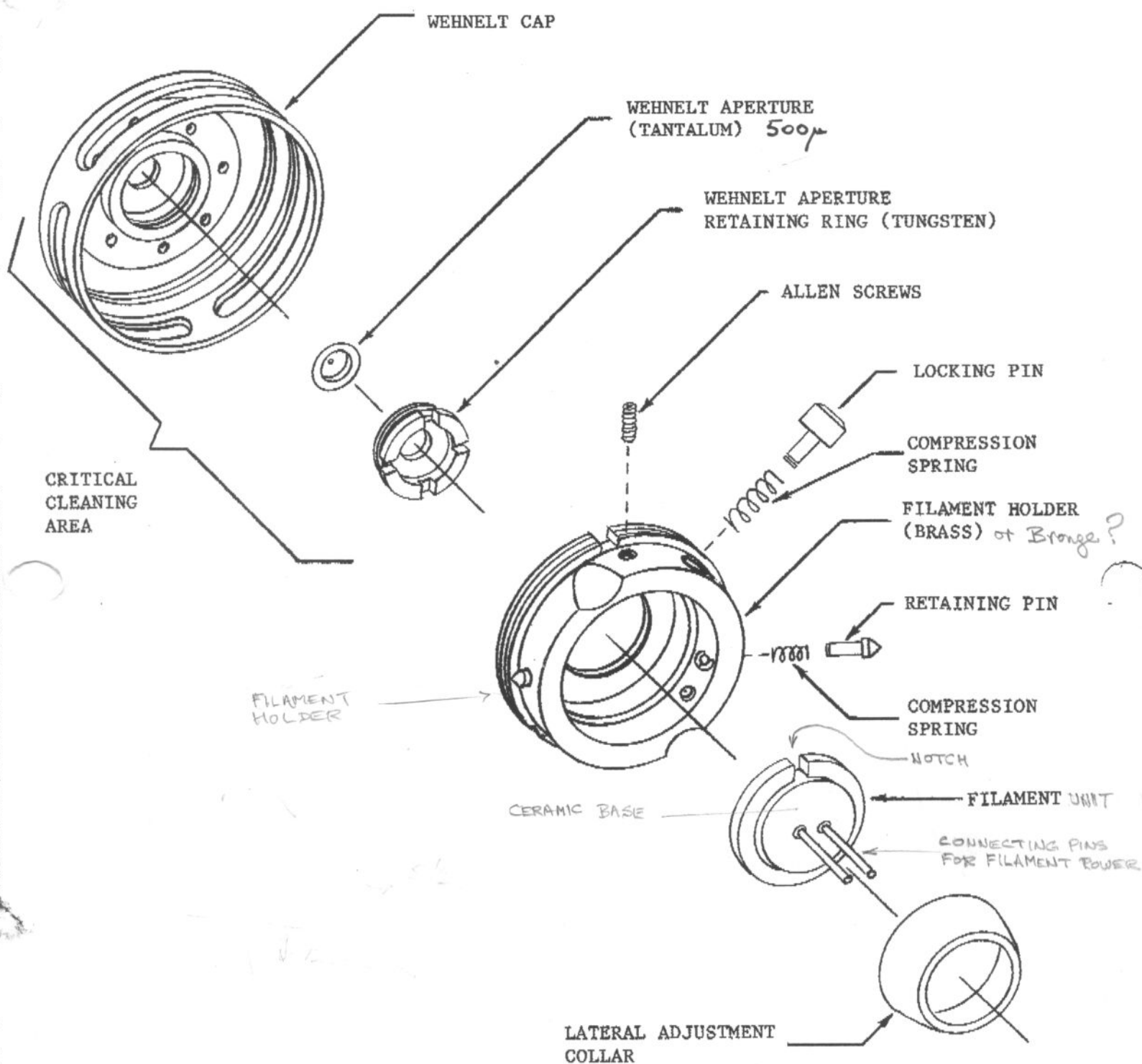


Figure 4.1A Tungsten Filament

ROUTINE MAINTENANCE AND SERVICE PROCEDURES

Electron Gun Filament Replacement (Cont.)

22. Re-check filament centering. Recenter if necessary.
23. Snap the Wehnelt assembly onto the Wehnelt support. Do not twist or turn the Wehnelt cap once it is in place.
24. Re-install the complete gun assembly onto the emission chamber. Make certain no dust or lint has collected on the O-ring.
25. Depress (vent) to pump the specimen and column. The (vent) light will go out and the mechanical pump will start.
Note: See Section (4-B) if ion-pump is present.
or 2-B? (page 24)
26. After one or two minutes, a low VAC green light will illuminate. Wait another few minutes to start the ion pump.
How many?
27. With the instrument in the Hi-Vac mode, it is ready to obtain the electron beam.
HI VAC Green LED on?
28. The filament should saturate at a gun emission of 100-150uA at 30 KV. If the new filament saturates at a current which is 50uA too high or low, the gun bias voltage control located at the front bottom of the electronics console can be adjusted.

N. Suggestions for Optimum Filament Performance

DO saturate properly. The most important factor regarding filament life is saturation. 1/10 of a division of the filament saturation knob equates to 10% of the filaments life. This means a filament which saturates at 6.0 would burn out in half the time if saturated at 6.5.

DO expect the emission current to drop 10-20uA in the first few hours of operation.

DO take an extra few minutes when cleaning gun parts. This is where the electron beam originates.

DO vent with dry nitrogen gas.

DO adjust the (Gun Bias) at low KV operation. Remember to turn it back down when returning to 20-30KV.

DO NOT try to take short cuts when cleaning gun parts.

DO NOT rush to turn a new filament on. Wait for proper Hi-Vac levels.

ROUTINE MAINTENANCE AND SERVICES PROCEDURES

Electron Gun Filament Replacement (Cont.)

DO NOT twist the gun cable.

DO NOT expect the tantalum Wehnelt aperture to last forever. This must be replaced periodically (AMRAY replacement part 107-005).

SECTION SIX

LIST OF REFERENCES

LIST OF REFERENCES*

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LIST OF REFERENCES (Cont.)

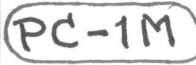
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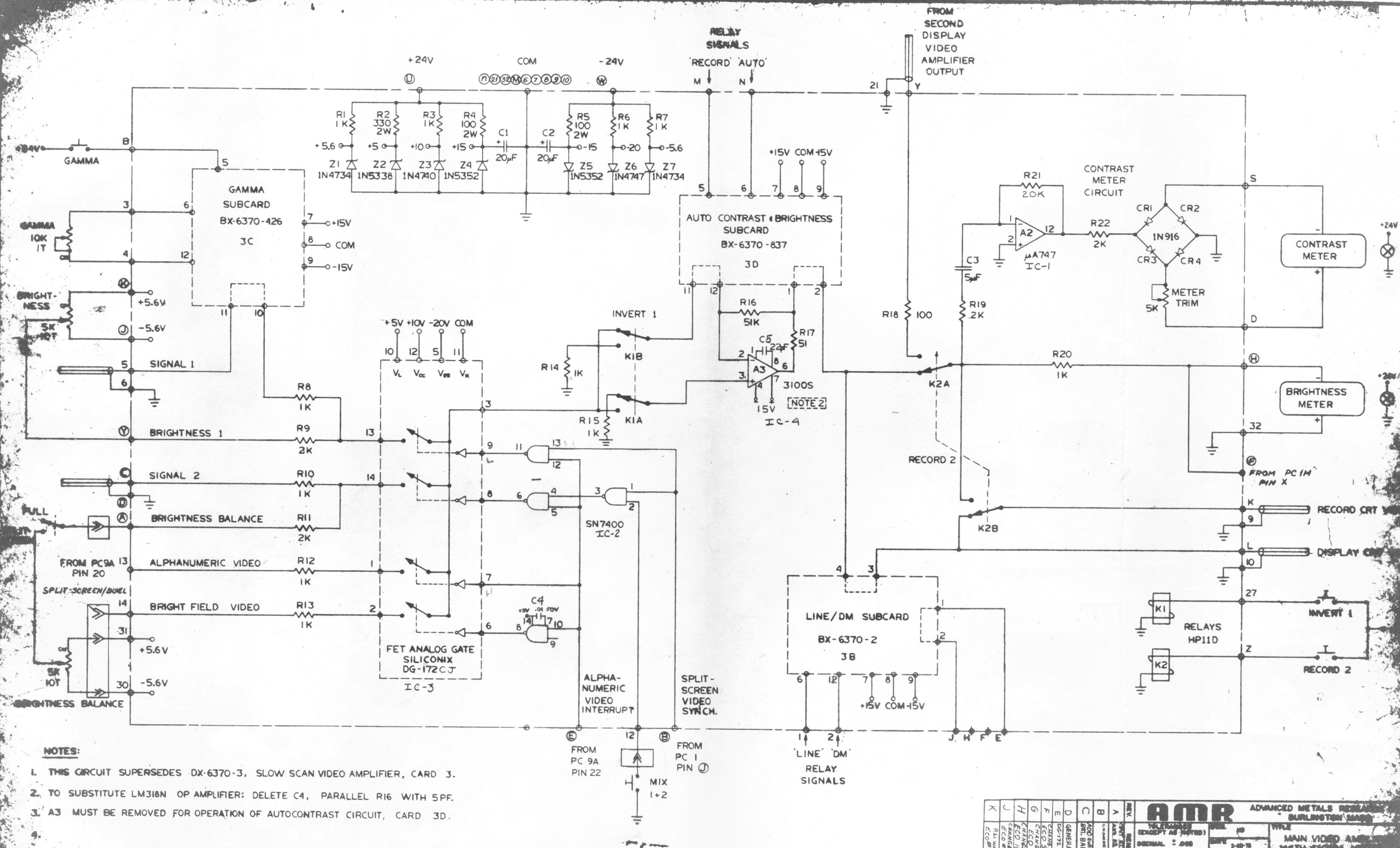
LIST OF REFERENCES (Cont.)

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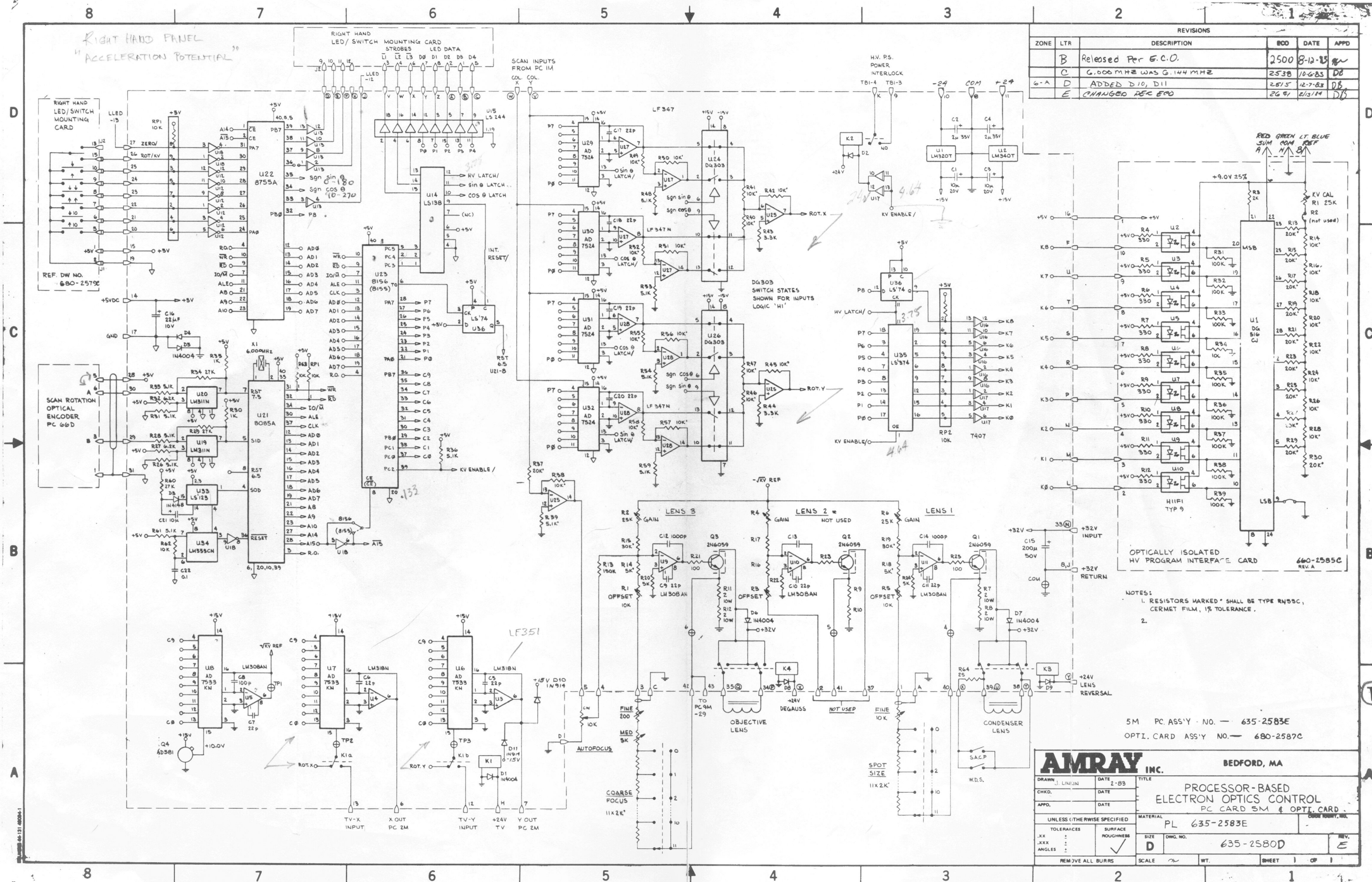
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* This list is not intended to be exhaustive. Its chief purpose is to introduce the reader to the abundant literature dealing with scanning electron microscopy. Sources marked with asterisk are highly recommended.





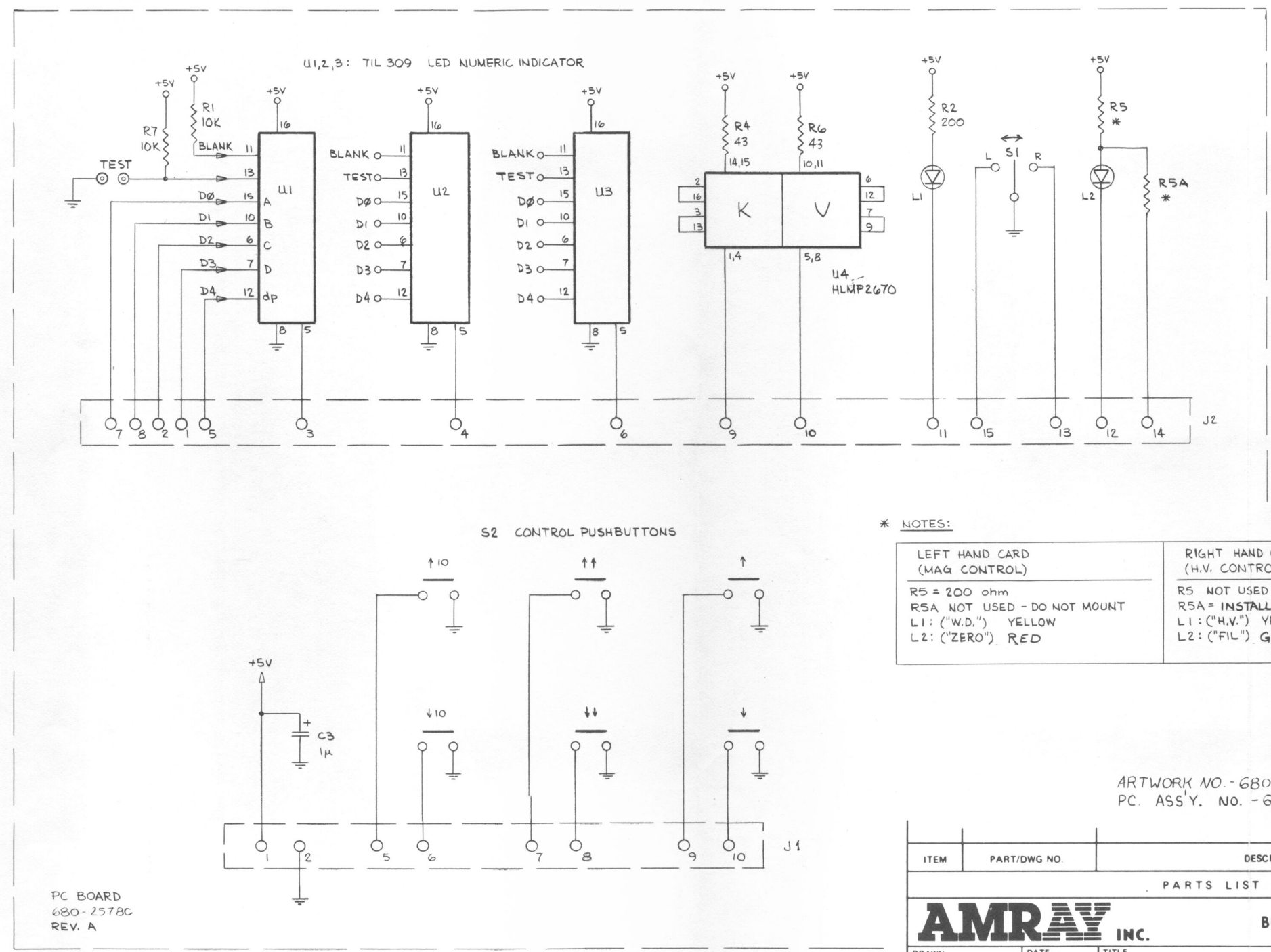
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CV	100	1-10-78	1-10-78	1-10-78	1-10-78



5 4 3 2 1

APPLICATION		REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE APPD
680-2643C		A	Released Per FLO	2500	8-12-83
		B	RED WAS GREEN/ GREEN WAS RED	2522	9-16-83

D
C
B
A



* NOTES:

LEFT HAND CARD (MAG CONTROL)	RIGHT HAND CARD (H.V. CONTROL)
R5 = 200 ohm	R5 NOT USED - DO NOT MOUNT
R5A NOT USED - DO NOT MOUNT	R5A = INSTALL JUMPER WIRE
L1: ("W.D.") YELLOW	L1: ("H.V.") YELLOW
L2: ("ZERO") RED	L2: ("FIL") GREEN

ARTWORK NO. - 680-2578C
PC ASSY. NO. - 680-2643C

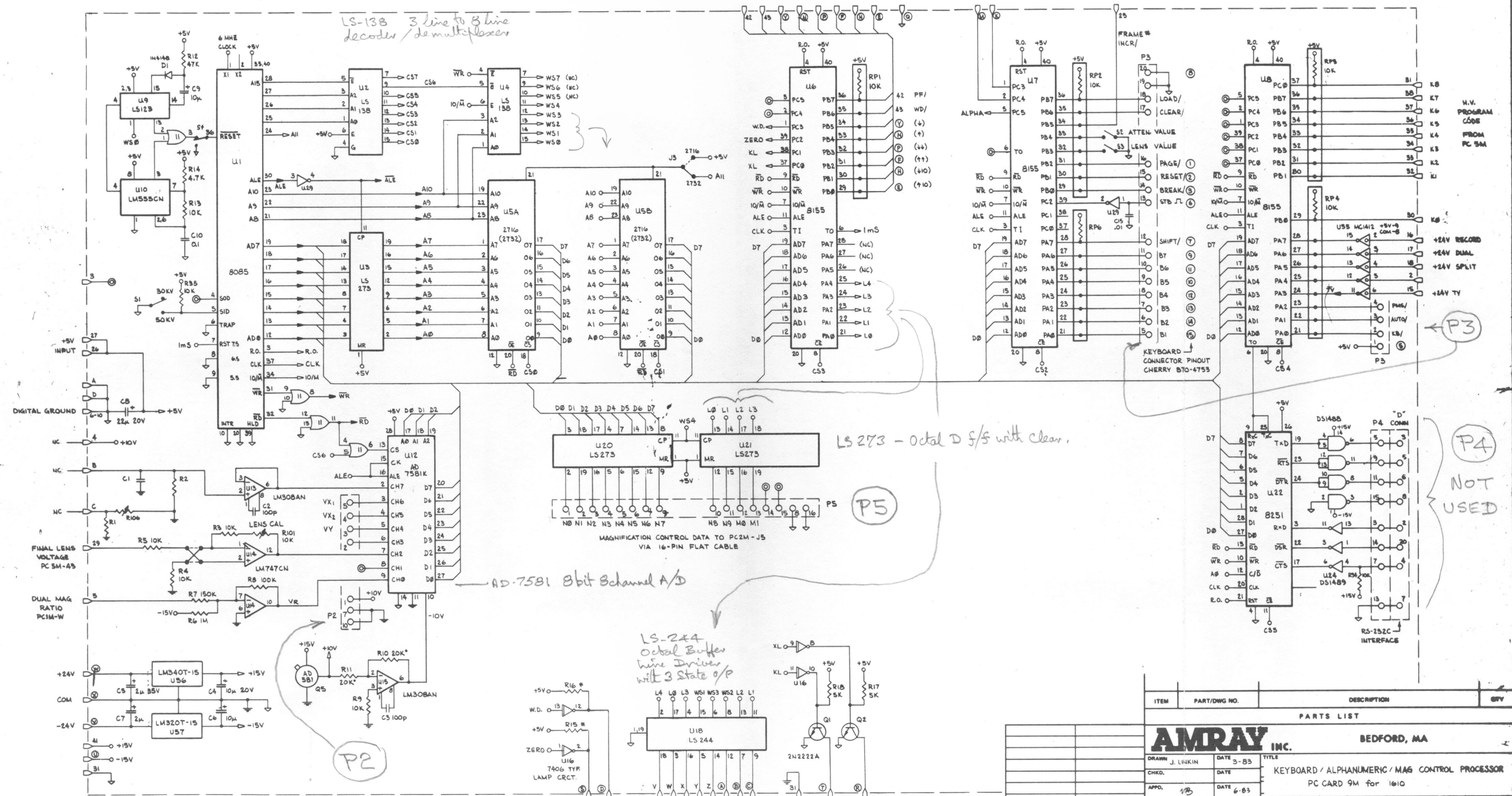
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AMRAY INC. BEDFORD, MA			
DRAWN	J. LINKIN	DATE	5-83
CHKD.		DATE	
APPD.		DATE	
UNLESS OTHERWISE SPECIFIED		MATERIAL	CODE IDENT. NO.
TOLERANCES		PL 680-2643C, -1 MAG	
XX ±		-2 ACCEL	
XXX ±			
ANGLES ±			
SURFACE ROUGHNESS		SIZE	DWG. NO.
✓		C	680-2579C
REMOVE ALL BURRS		SCALE	WT.
		SHEET	OF
		1	1

BRUNING 44-131 45094-1

5 4 3 2 1

LEFT-HAND PANEL
"MAGNIFICATION"
See Dwg. 680-2579 C

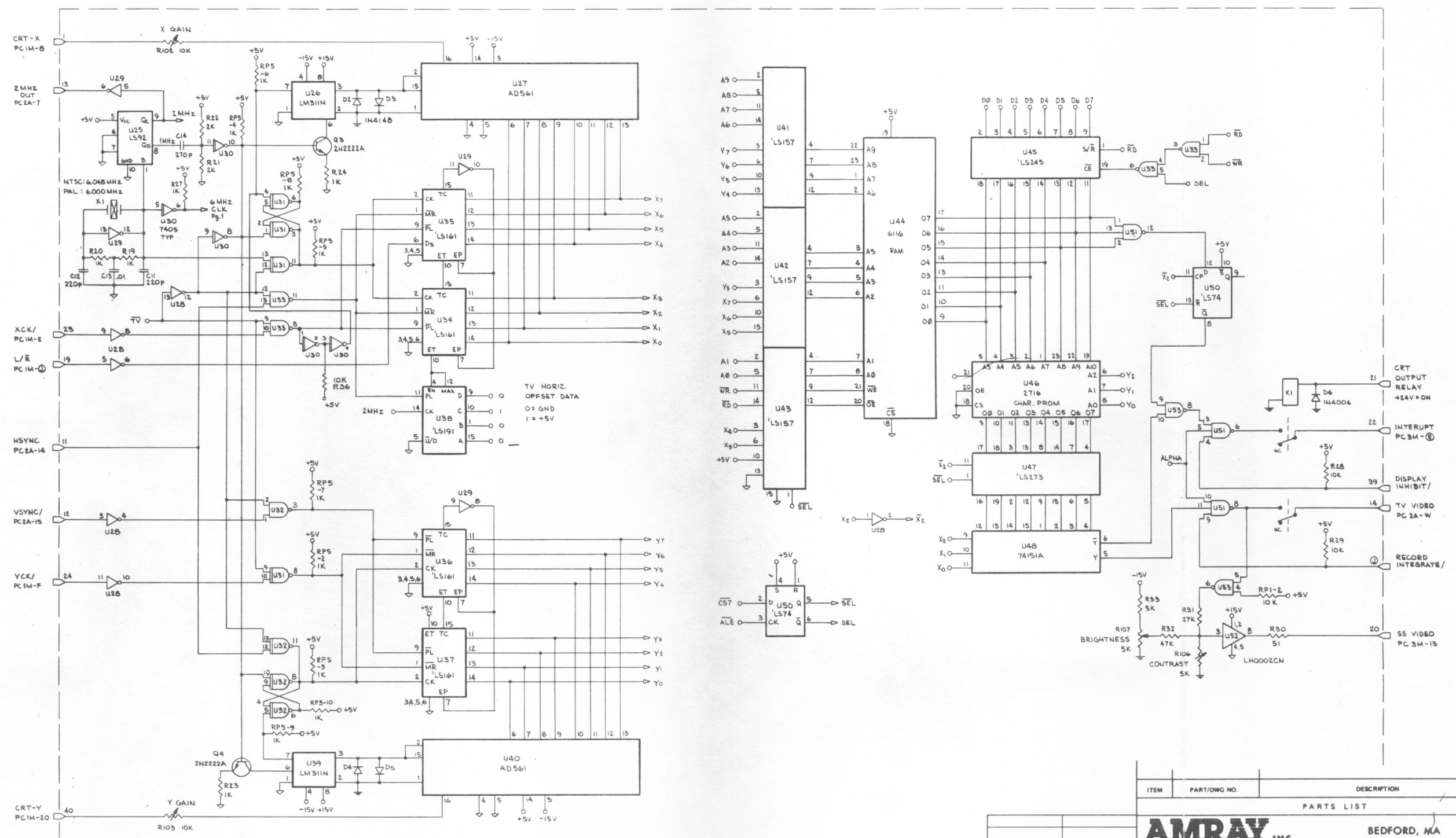
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C		CHANGED SHEET 2	2627	12-14-83



ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMRAY INC. BEDFORD, MA			
TITLE: KEYBOARD / ALPHANUMERIC / MAG CONTROL PROCESSOR			
PC CARD 9M for 1010			
MATERIAL: PL-6348-2638 Rev A			
SIZE: D DWG. NO. 648-2637D			
SCALE: WT. SHEET 1 of 2			

PC-9M
SHEET-1

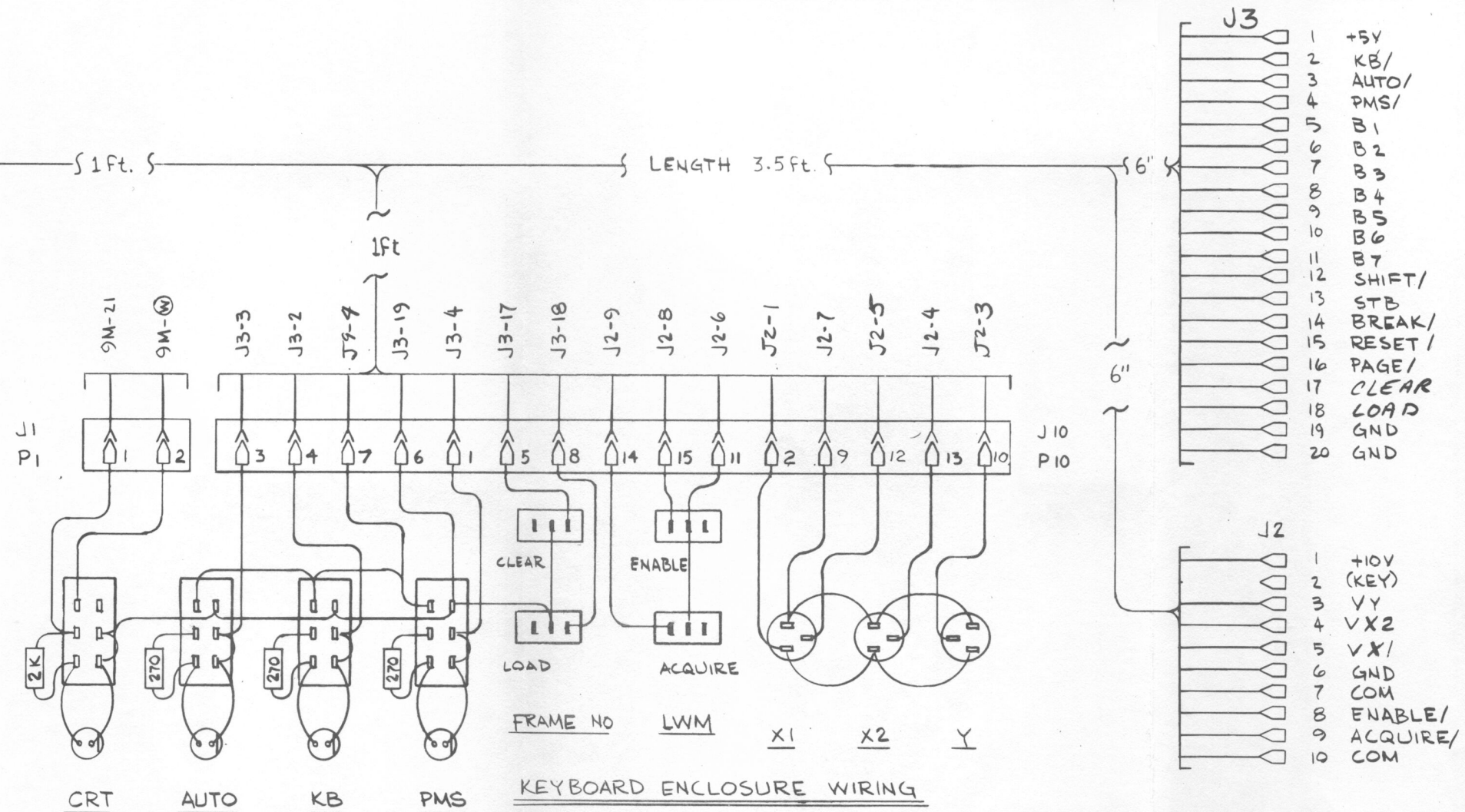
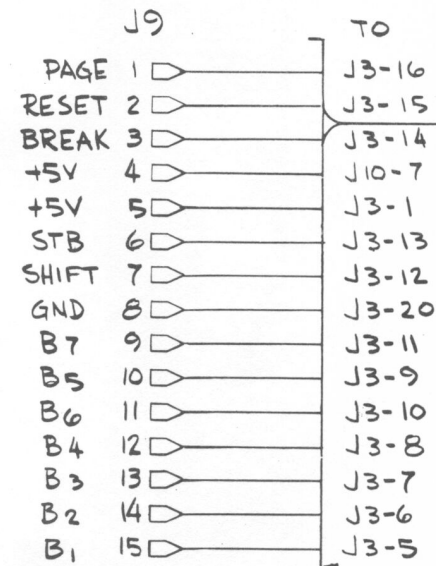
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	B	Released Per ECO	3500	8-10-83
6-C	C	ADDED R36	2627	12-14-83



ITEM	PART/DWG. NO.	DESCRIPTION	QTY
PARTS LIST			
AMRAY INC. BEDFORD, MA DRAWN J. LINKIN DATE 3-83 CHKD. DATE APPD. DATE 6-83 UNLESS OTHERWISE SPECIFIED TOLERANCES SURFACE FINISH .XX : : .XXX : : ANGLES : : USED ON APPLICATION REMOVE ALL BURRS			
TITLE KEYBOARD / ALPHANUMERIC / MAB READOUT PROCESSOR PC CARD 9M for 1610 MATERIAL PL-6348-2638 Rev A SIZE DWG. NO. 648-2637D SCALE WT. SHEET 2 OF 2			

PC-9M
SHEET-2

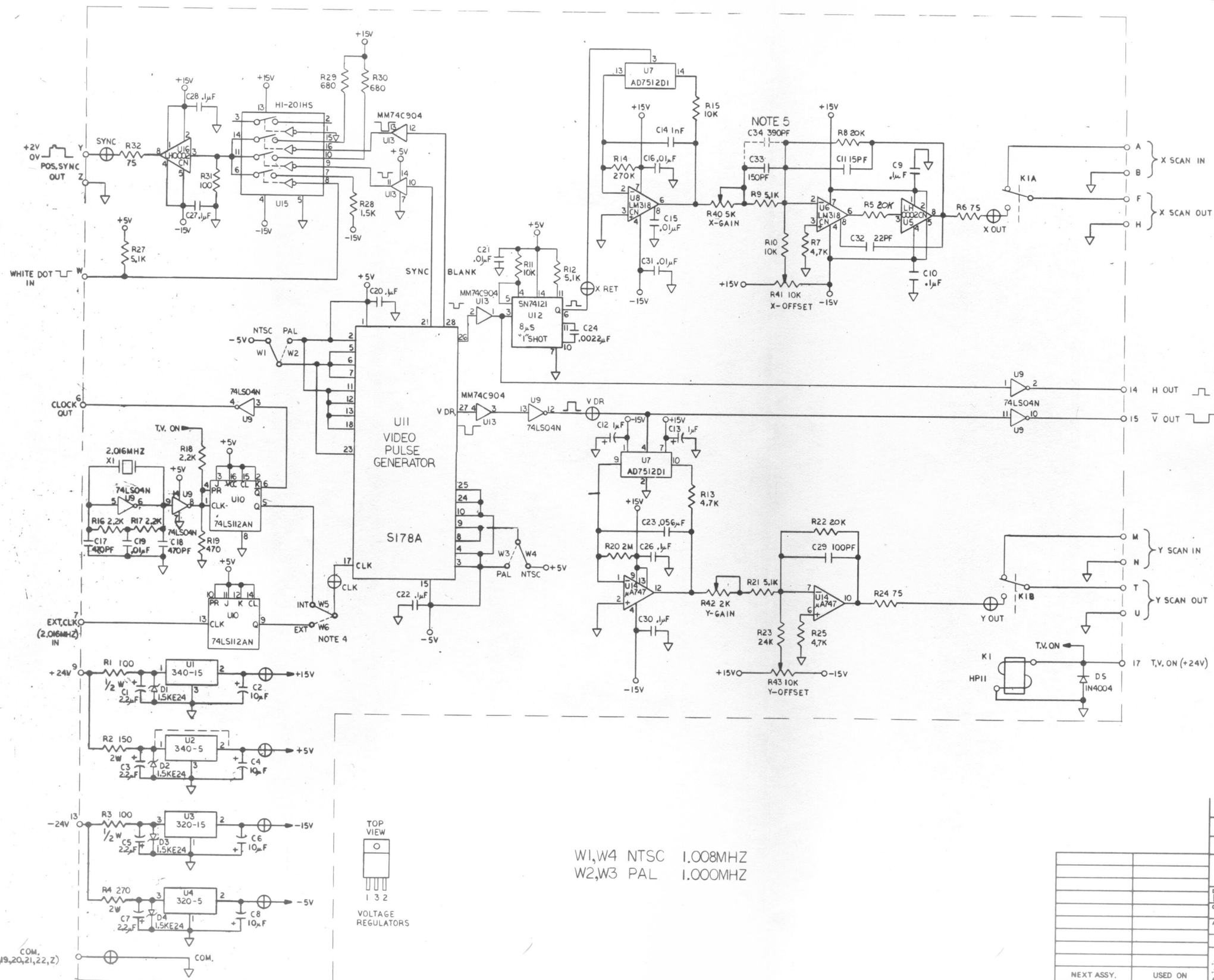
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	648-1450D	A	RELEASE PER ECO	2500	8/17/83	PLB
		B	MANY CHANGES SEE ECO	2777	9/30/84	PLB
		C	2 WAS 9, 9 WAS 2, 12 WAS 10, 10 WAS 12	2931	11-1-84	



- NOTES:
1. FLAT SIDE OF LED'S IS CATHODE END.
 2. ALL CONTROLS VIEWED FROM REAR.
 3. RESISTORS, 1/4W 5% CARBON COMP.
 4. ALL WIRING AWG. # 22

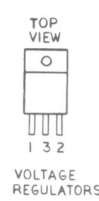
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DRAWN J. LINKIN	DATE 2-83	TITLE	
CHKD.	DATE	KEYBOARD SYSTEM INTERCONNECTIONS	
APPD. KB	DATE 6-83		
UNLESS OTHERWISE SPECIFIED		CODE IDENT. NO.	
TOLERANCES	SURFACE ROUGHNESS	FOR SEM 1610	
.XX ±	✓	PLB-6348-2609	
.XXX ±		SIZE B	DWG. NO. 648-2609 B
ANGLES ±		SCALE	REV. C
REMOVE ALL BURRS		WT.	SHEET 1 OF 1

REVISIONS					
ZONE	LTR	DESCRIPTION	ECO	DATE	APPD
		RELEASE TO PRODUCTION	2238	10-28-82	W. S.
A		R5 OUT PUT CHANGE	2354	3-7-83	P. G.

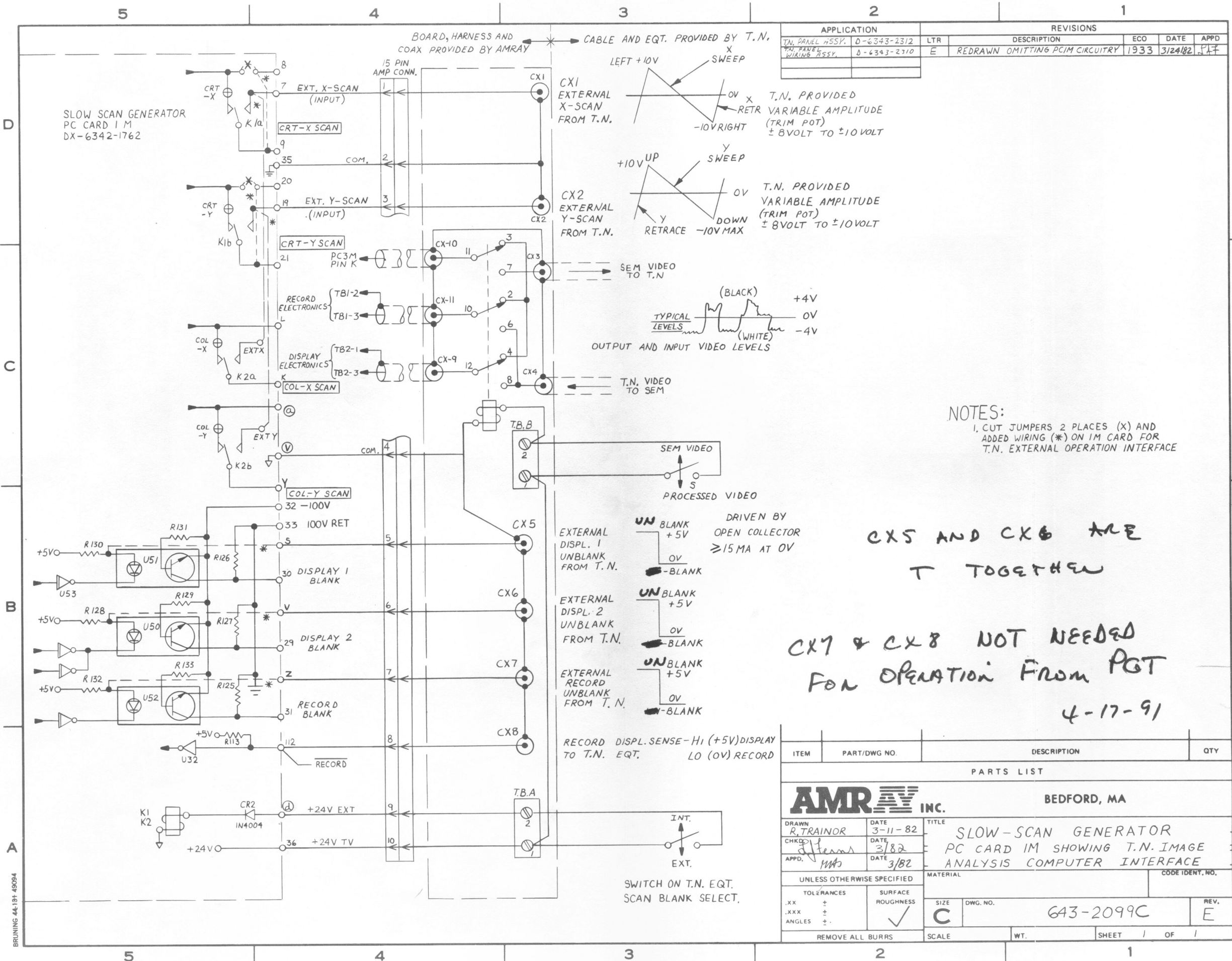


- NOTES:
1. RELAYS SHOWN UNENERGIZED.
 2. ALL RESISTORS ARE 5% 1/4W UNLESS SPECIFIED.
 3. SYSTEM SHOWN FOR NTSC STANDARD. FOR PAL CUT W1&W4, JUMPER W2&W3 AND CHANGE CRYSTAL TO 2.00 MHZ.
 4. FOR EXT. CLK, CUT W5 AND ADD JUMPER W6.
 5. FOR SEM 1200 & 1700 ADD CAPACITOR C34 390PF.

W1,W4 NTSC 1.008MHZ
W2,W3 PAL 1.000MHZ



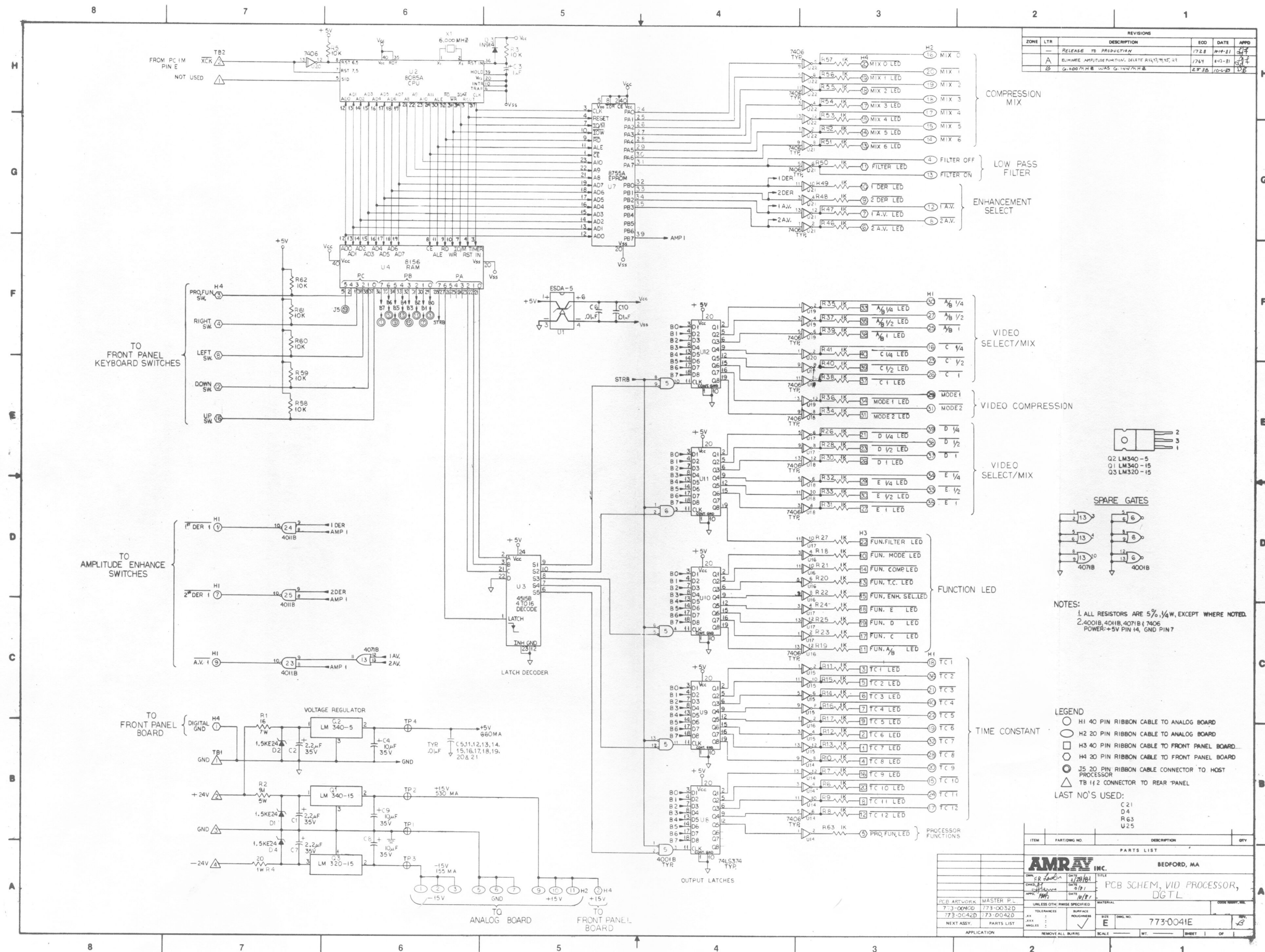
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PARTS LIST			
AMRAY INC. BEDFORD, MA			
DRAWN: R. TRAINOR CHKD: W. S. Gage APPD:	DATE: 1-8-82 DATE: 10-27-82 DATE:	TITLE: UNIVERSAL FSTV SYNC-SCAN GENERATOR SCHEMATIC	
UNLESS OTHERWISE SPECIFIED		MATERIAL	
TOLERANCES	SURFACE FINISH	SIZE	DWG. NO.
.XX	✓	D	152-1427 D
ANGLES		SCALE	WT.
NEXT ASSY.	USED ON	SHEET	OF
APPLICATION		REMOVE ALL BURRS	



I think - mfm.

TN
Tracor Northern

PGT
Princeton Gamma Tech



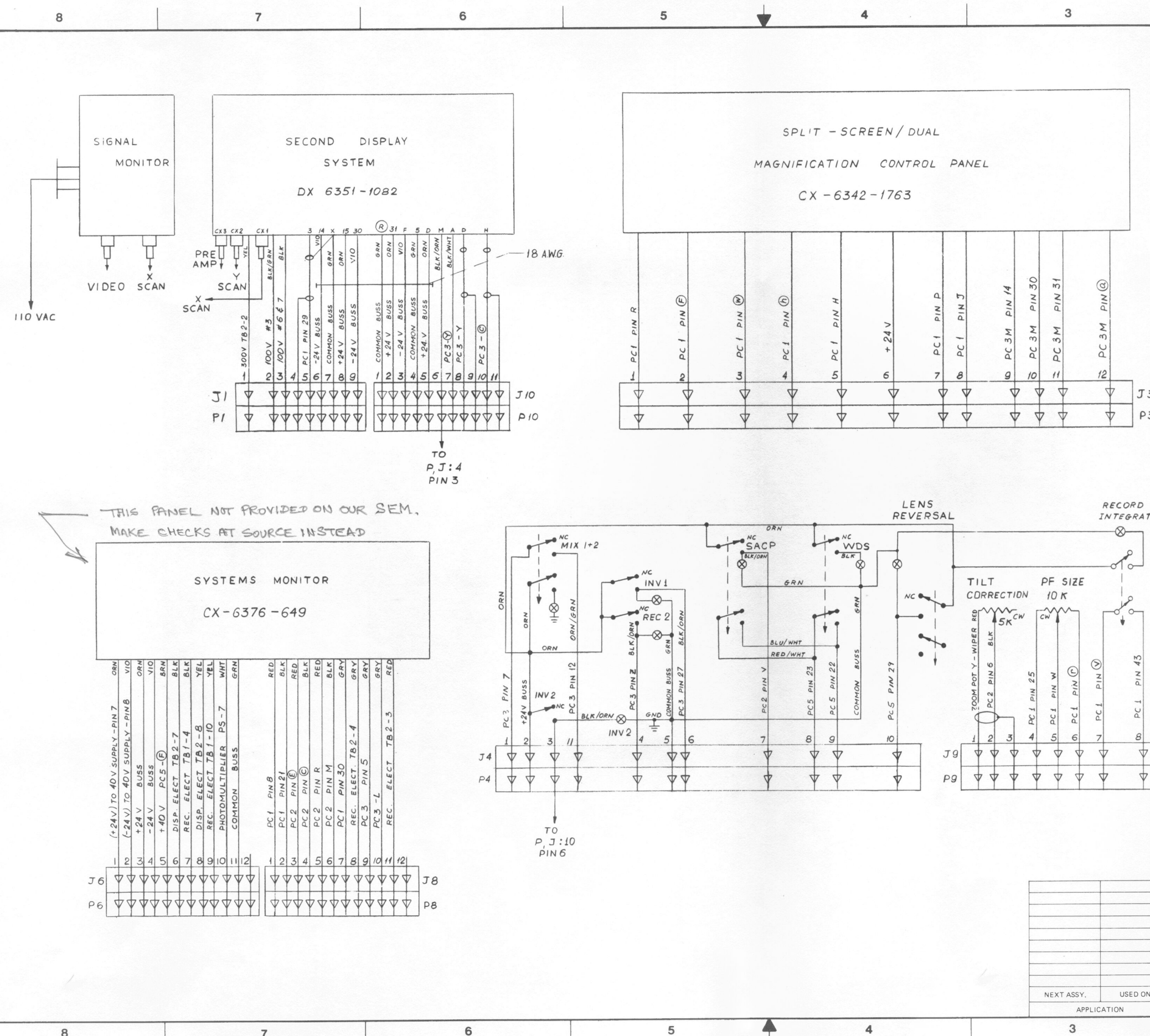
REVISIONS					
ZONE	LTR	DESCRIPTION	ECO	DATE	APPD
	F	CHANGE PER ECO 881 NEW CONN.	881	7-2-79	
	G	ADD LAMP AND CHANGE SWITCH (REC INTEGR)	887	7-11-79	
	H	CHANGE PER ECO 966	966	8-15-79	JBM

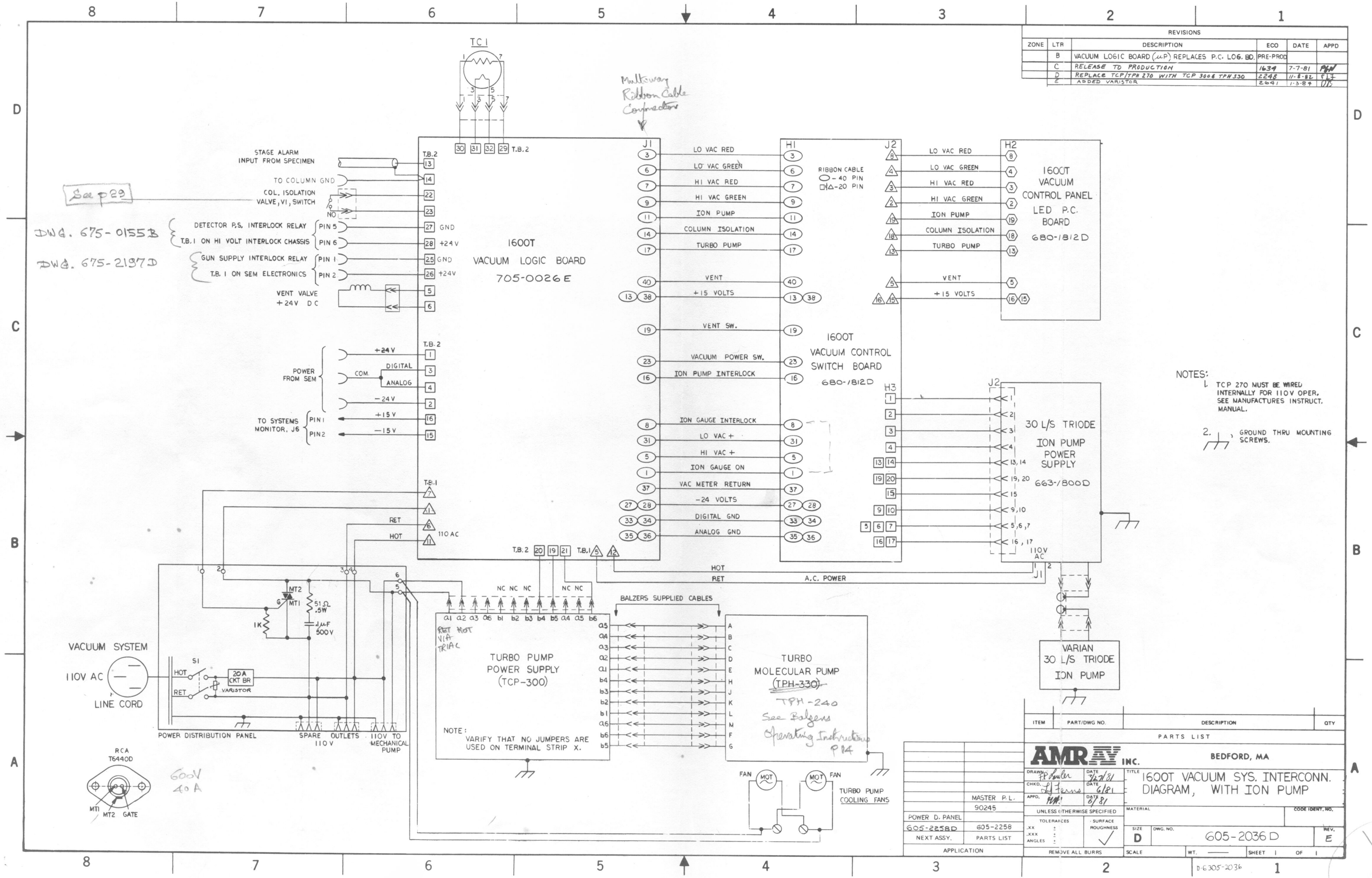
NOTES:

1. ALL PLUGS ARE AMP UNIV 15 CHT PLUGS
2. ALL JACKS ARE AMP UNIV 15 CHT CAPS
3. ALL CONNECTORS TO BE CLEARLY MARKED WITH P OR J NUMBER
4. IF TILT CORRECTION IS NOT INSTALLED JUMPER PIN 1 AND 2 OF P9
5. WIRING IS 22 AWG UNLESS NOTED

BEGINNING SN T7

ITEM		PART/DWG NO.		DESCRIPTION		QTY	
PARTS LIST							
AMR				ADVANCED METALS RESEARCH CORP BEDFORD, MASS.			
OWN. M GOLOSINSKY		DATE 6-29-79		TITLE UPPER DECK HARNESS INTERCONNECTION			
CHKD.		DATE		MATERIAL SEM. 1000 A			
APPD. D BERRY		DATE 7-5-79		CODE IDENT. NO.			
UNLESS OTHERWISE SPECIFIED							
TOLERANCES		SURFACE ROUGHNESS		SIZE D		DWG. NO. 683-1265D	
.XX ± .XXX ± ANGLES		✓		REV. H			
REWORK/ALL BURRS				SCALE 1/4		WT. 1/4	
				SHEET 1		OF 1	





REVISIONS					
ZONE	LTR	DESCRIPTION	ECO	DATE	APPD
B		VACUUM LOGIC BOARD (uP) REPLACES P.C. LOG. BD.	PRE-PROD		
C		RELEASE TO PRODUCTION	1639	7-7-81	PH
D		REPLACE TCP/TPH 270 WITH TCP 300 & TPH 330	2248	11-8-82	PL
E		ADDED VARISTOR	2691	1-3-84	DT

- NOTES:
- 1. TCP 270 MUST BE WIRED INTERNALLY FOR 110V OPER. SEE MANUFACTURER'S INSTRUCT. MANUAL.
 - 2. GROUND THRU MOUNTING SCREWS.

ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMRAY INC. BEDFORD, MA			
DRAWN: <i>[Signature]</i> DATE: 3/27/81		TITLE: 1600T VACUUM SYS. INTERCONN. DIAGRAM, WITH ION PUMP	
CHKD: <i>[Signature]</i> DATE: 6/81		MATERIAL: _____	
APPD: <i>[Signature]</i> DATE: 6/81		CODE IDENT. NO.: _____	
MASTER P.L. 90245		UNLESS OTHERWISE SPECIFIED	
POWER D. PANEL 605-2258D		TOLERANCES: .XX : SURFACE : .XXX : ROUGHNESS : ✓	
NEXT ASSY. PARTS LIST		SIZE: D DWG. NO. 605-2036 D	
APPLICATION		SCALE: _____	
		WT. _____ SHEET 1 OF 1	

See p 22

DWG. 675-0155B

DWG. 675-2197D

TURBO PUMP POWER SUPPLY (TCP-300)

NOTE: VERIFY THAT NO JUMPERS ARE USED ON TERMINAL STRIP X.

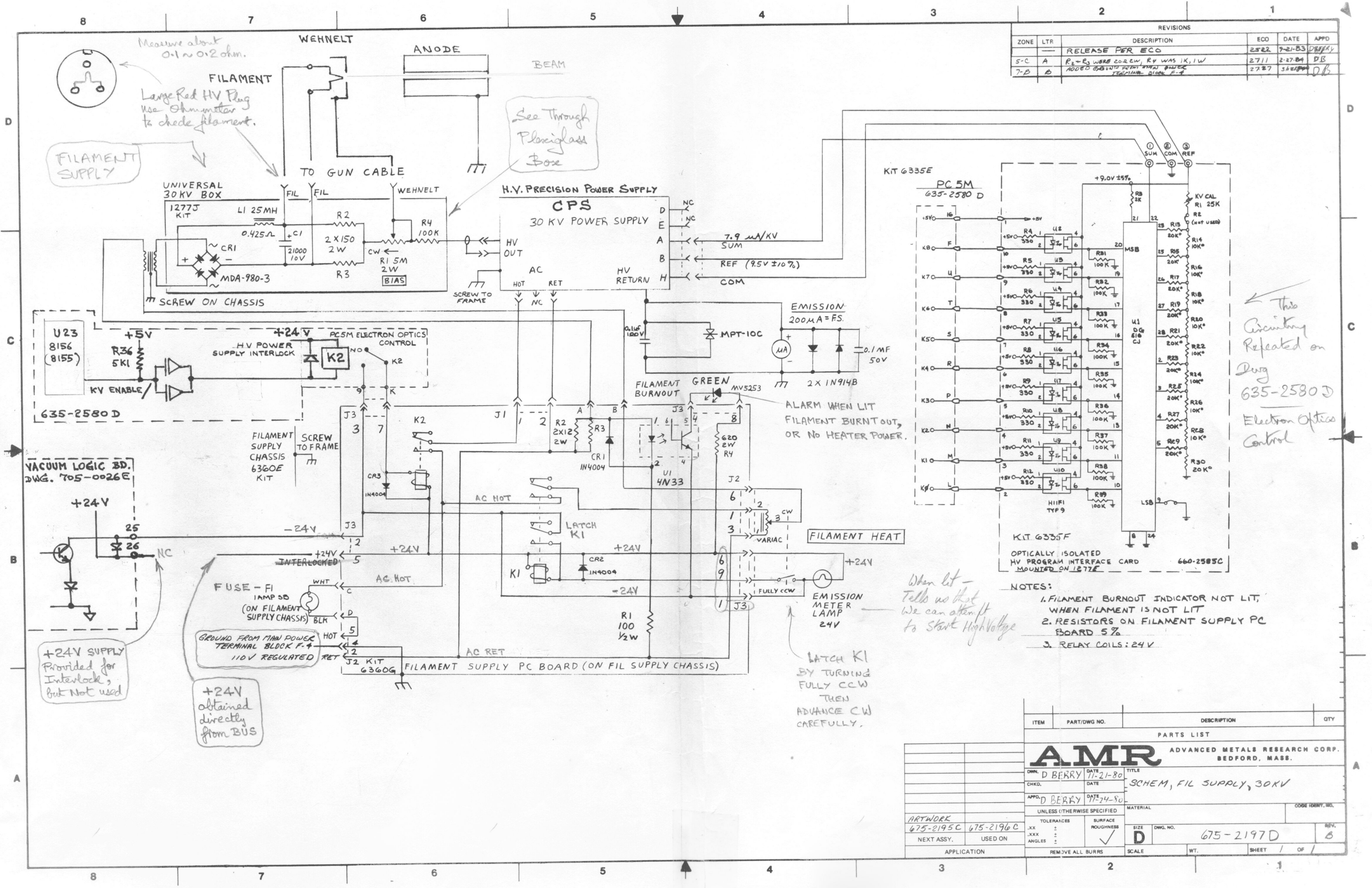
TURBO MOLECULAR PUMP (TPH-330)

TPH-240

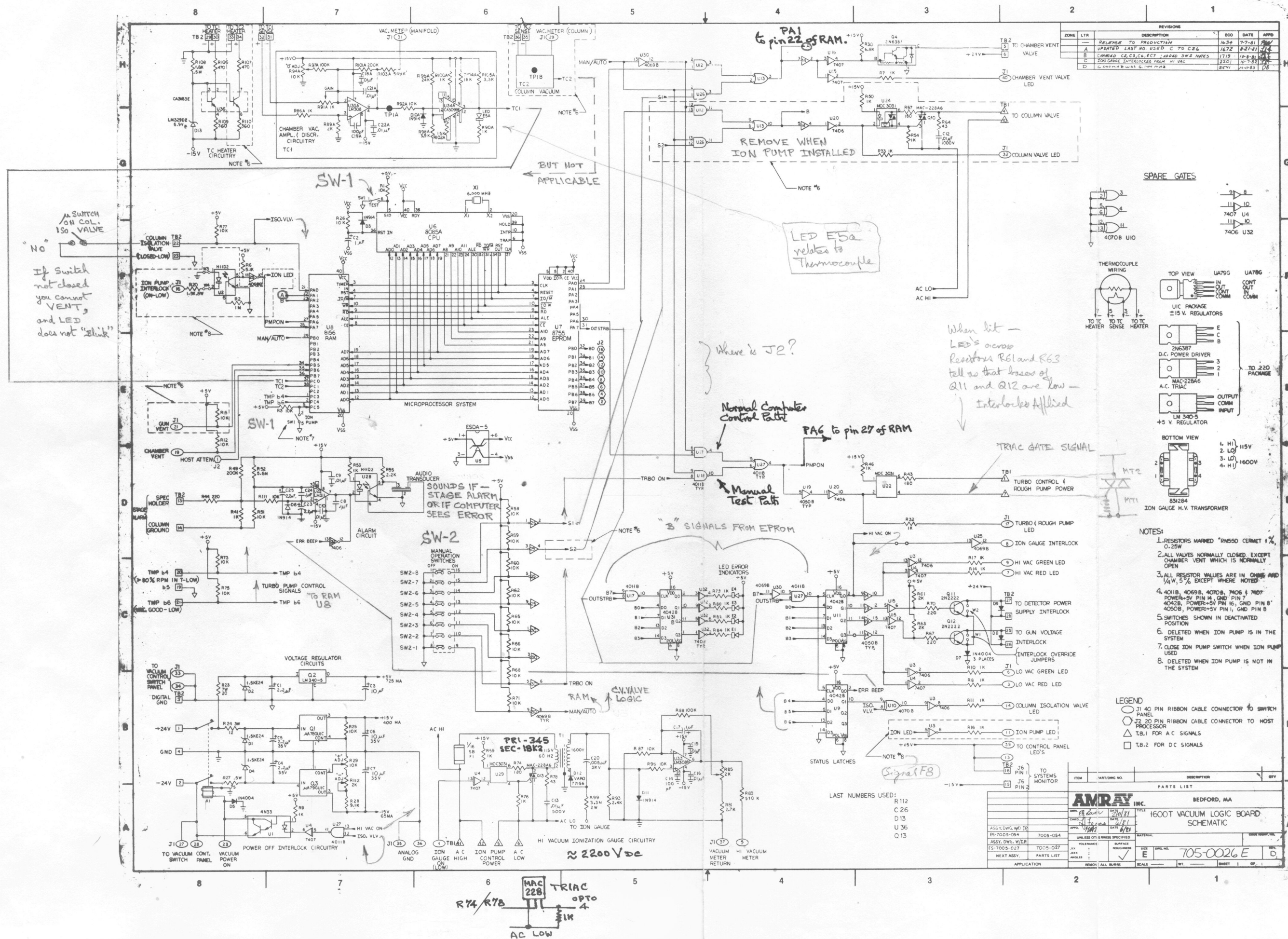
See Balzers Operating Instructions P14

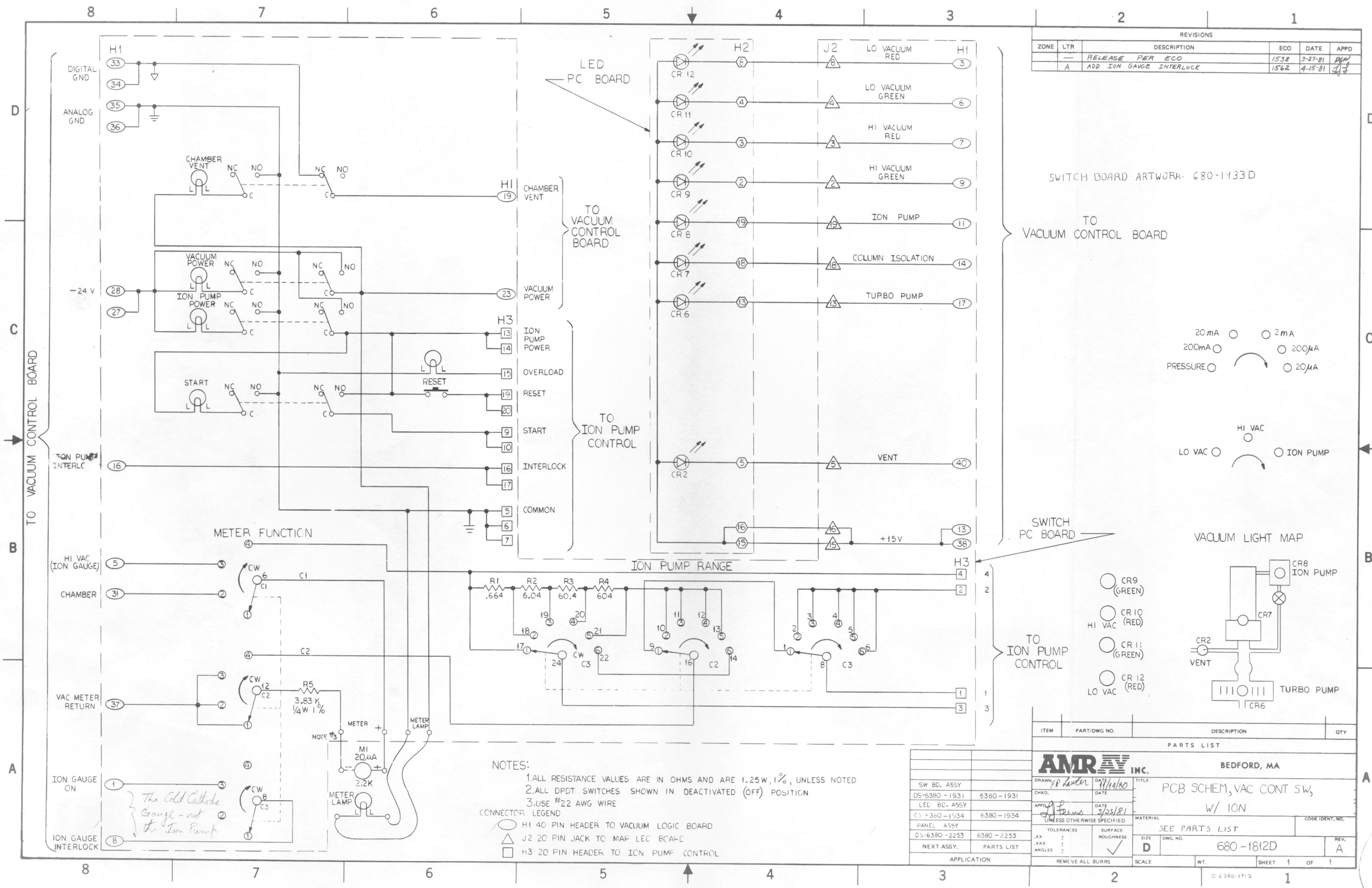
VARIAN 30 L/S TRIODE ION PUMP

REVISIONS				
ZONE	LTR	DESCRIPTION	ECO	DATE
5-C	A	RELEASE PER ECO	2522	7-21-83
7-D	A	R ₂ +R ₃ WERE 202CW, R ₄ WAS 1K, 1W	2711	2-27-84
		ADDED GREEN LED FILAMENT BURNOUT	2727	3-22-84
		TECHNICAL DRAWING F-4		



ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMR ADVANCED METALS RESEARCH CORP. BEDFORD, MASS.			
DWG.	D BERRY	DATE	7-21-80
CHKD.		DATE	
APPD.	D BERRY	DATE	7-24-80
UNLESS OTHERWISE SPECIFIED		MATERIAL	CODE IDENTIFY, IRL
TOLERANCES	XX	SURFACE ROUGHNESS	✓
ANGLES	XX	SIZE	D
APPLICATION	675-2195C 675-2196C	DWG. NO.	675-2197D
NEXT ASSY.	USED ON	SCALE	WT.
REMOVING ALL BURRS		SHEET	1 OF 1

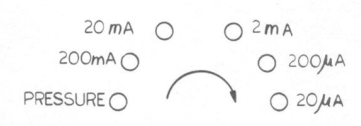




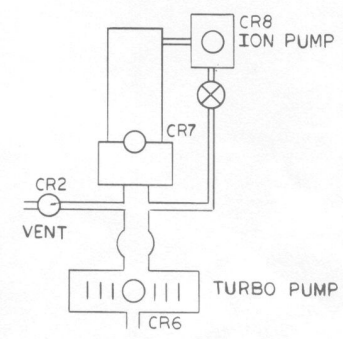
REVISIONS					
ZONE	LTR	DESCRIPTION	ECO	DATE	APPD
		RELEASE PER ECO	1538	3-27-81	PM
A		ADD ION GAUGE INTERLOCK	1562	4-15-81	PM

SWITCH BOARD ARTWORK: 680-1933D

TO VACUUM CONTROL BOARD



VACUUM LIGHT MAP



- CR 9 (GREEN)
- CR 10 (RED)
- CR 11 (GREEN)
- CR 12 (RED)
- HI VAC
- LO VAC

NOTES:
1. ALL RESISTANCE VALUES ARE IN OHMS AND ARE 1.25W, 1%, UNLESS NOTED
2. ALL DPDT SWITCHES SHOWN IN DEACTIVATED (OFF) POSITION
3. USE #22 AWG WIRE

CONNECTOR LEGEND
○ H1 40 PIN HEADER TO VACUUM LOGIC BOARD
△ J2 20 PIN JACK TO MAP LED BOARD
□ H3 20 PIN HEADER TO ION PUMP CONTROL

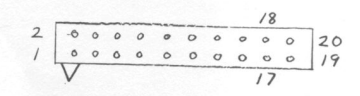
ITEM	PART/DWG NO.	DESCRIPTION	QTY
SW BD. ASSY			
DS-6380-1931	6380-1931		
LED BD. ASSY			
CS-300-1934	6380-1934		
PANEL ASSY			
DS-6380-2253	6380-2253		
NEXT ASSY.	PARTS LIST		

AMR INC.		BEDFORD, MA	
DRAWN: <i>JP</i>	DATE: 11/14/80	TITLE: PCB SCHEM, VAC CONT SW, W/ ION	
CHKD:	DATE:	MATERIAL: SEE PARTS LIST	
APPROV: <i>JP</i>	DATE: 3/25/81	CODE IDENT. NO.	
TOLERANCES: UNLESS OTHERWISE SPECIFIED		SIZE: D	
SURFACE: ✓		DWG. NO.: 680-1812D	
REWORK: REMOVE ALL BURRS		SCALE: 1	
WT.		SHEET 1 OF 1	

WITH ION PUMP

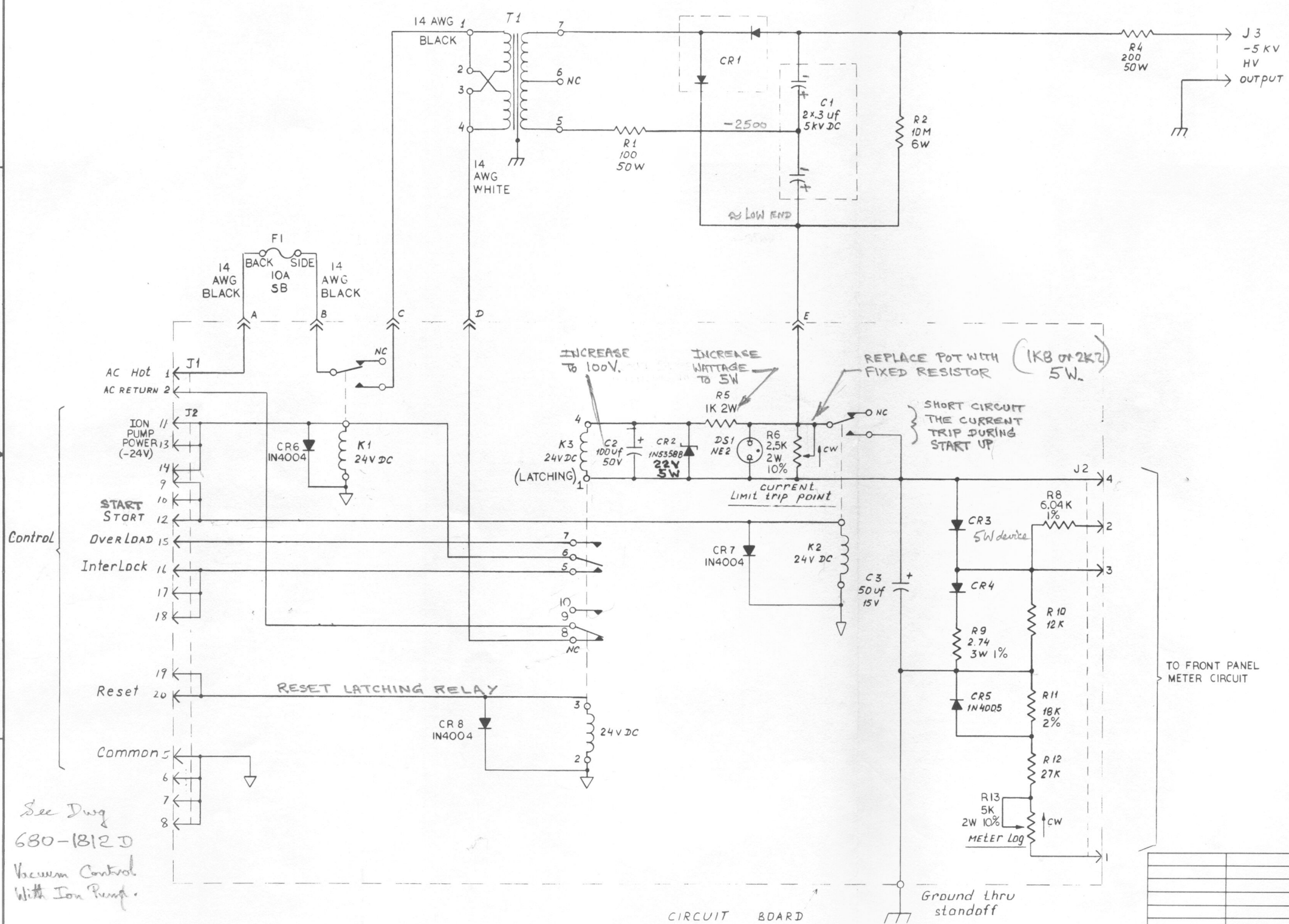
REVISIONS				
ZONE	LTR	DESCRIPTION	ECO	DATE
		RELEASE PER ECO	1-72	1-22-81
A		ADDED CR6, CR7, & CR8 TO CLAMP INDUCTIVE SPIKE	1653	7/17/81
C-7	B	10A SB WAS 10A FB	2423	5-3-81

J2 VIEWED FROM CABLE SIDE



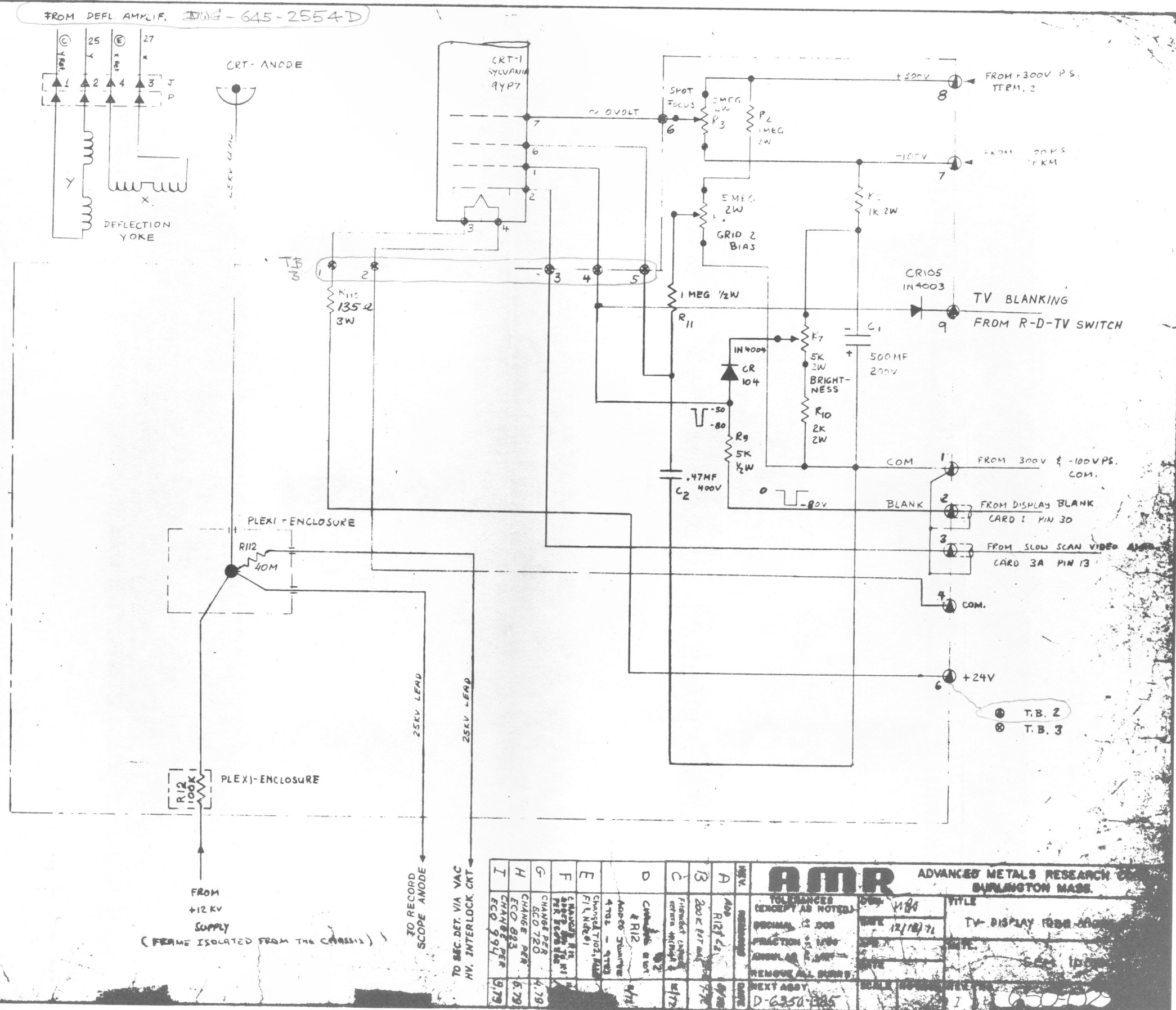
NOTES

- 110V CONNECTIONS SHOWN ON PRIMARY OF T1
- T1 TO BE GROUNDED TO CHASSIS THRU ONE MOUNTING LEG
- RELAY K3 IS SHOWN IN RESET POSITION
- K1 & K2 SHOWN IN UNENERGIZED POSITION
- ALL RESISTORS ARE 1/2 WATT EXCEPT WHERE NOTED
- ALL RESISTORS ARE 5% EXCEPT WHERE NOTED



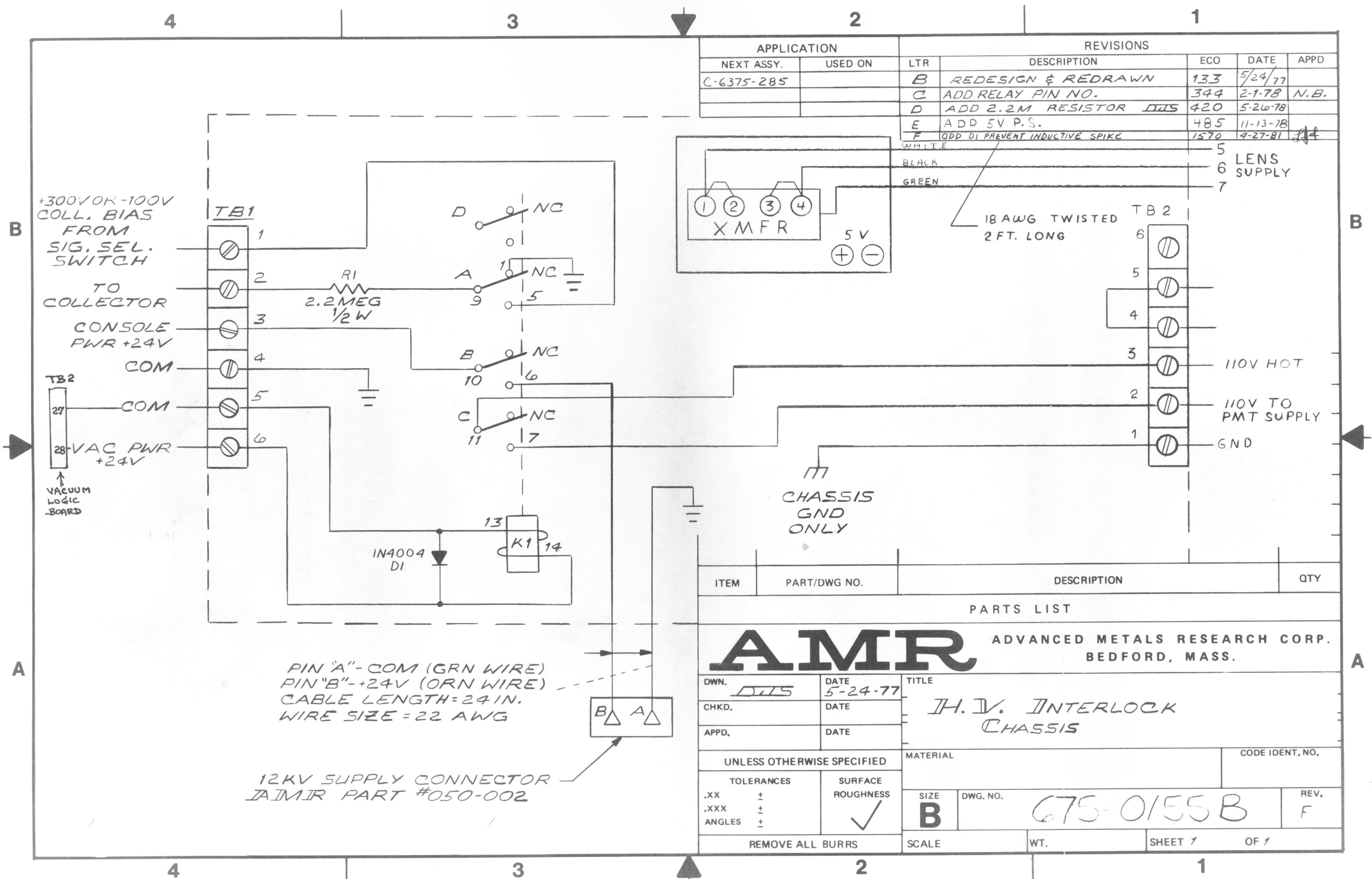
See Dwg 680-1812 D
Vacuum Control With Ion Pump.

ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMR ADVANCED METALS RESEARCH CORP. BEDFORD, MASS.			
DWN. M. Golezinski	DATE 1-9-79	TITLE 3D L/S TRIDDE ION PUMP POWER	
CHKD.	DATE	SUPPLY SCHEMATIC	
APPD. D. BERRY	DATE 3-79		
UNLESS OTHERWISE SPECIFIED		MATERIAL	CODE TERRY, NO.
TOLERANCES	SURFACE ROUGHNESS	SIZE	DWG. NO.
.XX ±	✓	D	680-1800D
ANGLES		SCALE	WT.
APPLICATION	REMOVE ALL BURRS	SHEET 1	OF 1



TV-DISPLAY

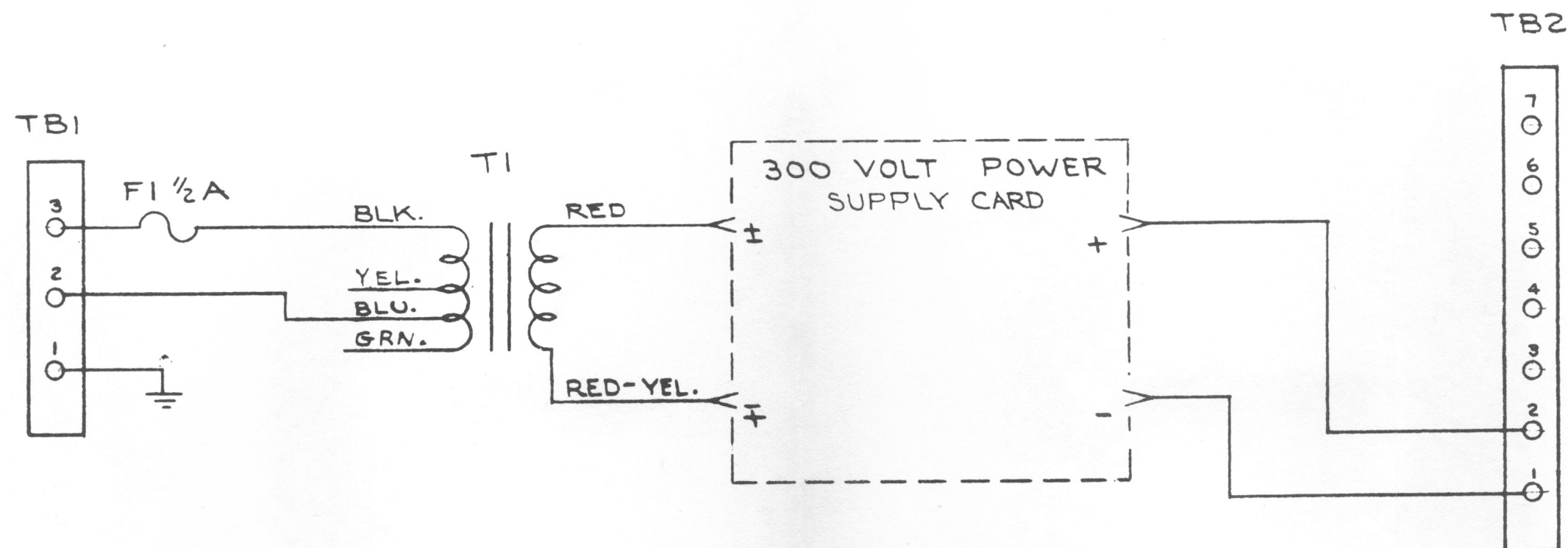
AMR										ADVANCED METALS RESEARCH CO.										BURLINGTON MASS.									
TOLERANCES (EXCEPT AS NOTED)															TITLE														
DECIMAL .005															DATE 12/18/71														
FRACTION 1/16															REV.														
ANGULAR .01															BY														
REMOVE ALL BURRS															CHECKED														
NEXT ASSY															DRAWN														
D-6350-105															SCALE														
															PART NO.														
															REV.														



APPLICATION		REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE APPD
C-6375-285		B	REDESIGN & REDRAWN	133	5/24/77
		C	ADD RELAY PIN NO.	344	2-1-78 N.B.
		D	ADD 2.2M RESISTOR <i>DJS</i>	420	5-26-78
		E	ADD 5V P.S.	485	11-13-78
		F	ADD DI PREVENT INDUCTIVE SPIKE	1570	9-27-81 <i>JH</i>

WHITE	5
BLACK	6
GREEN	7
18AWG TWISTED 2FT. LONG	
TB 2	
6	
5	
4	
3	110V HOT
2	110V TO PMT SUPPLY
1	GND

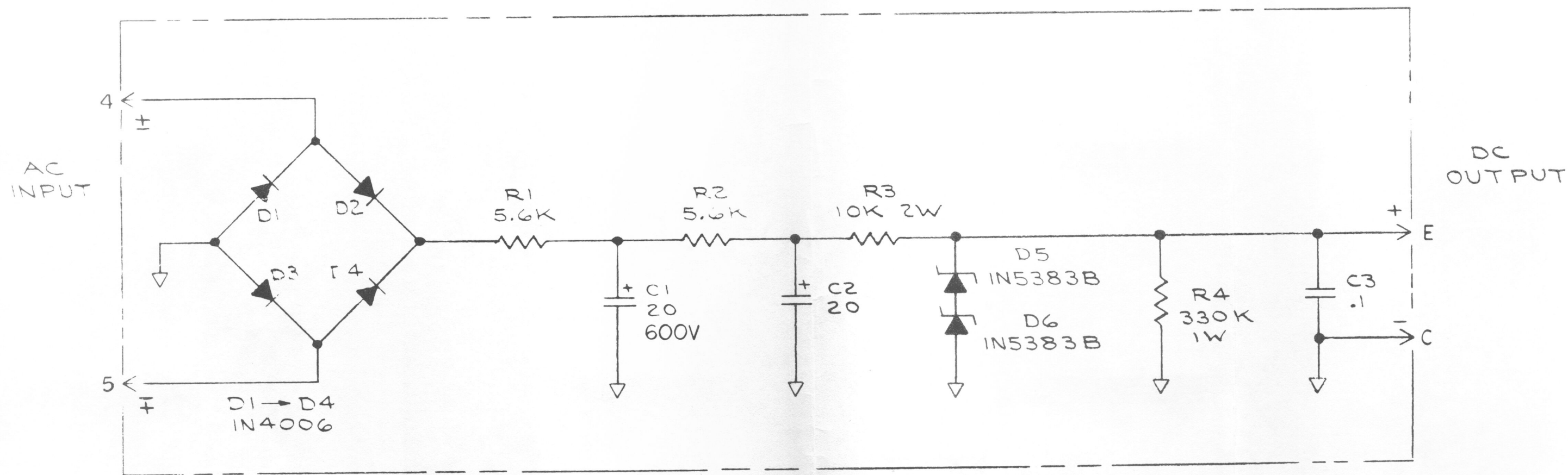
ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMR ADVANCED METALS RESEARCH CORP. BEDFORD, MASS.			
DWN. <i>DJS</i>	DATE 5-24-77	TITLE <i>H.V. INTERLOCK CHASSIS</i>	
CHKD.	DATE		
APPD.	DATE		
UNLESS OTHERWISE SPECIFIED		MATERIAL	CODE IDENT. NO.
TOLERANCES .XX ± .XXX ± ANGLES ±	SURFACE ROUGHNESS ✓	SIZE B DWG. NO. <i>675-0155B</i>	REV. F
REMOVE ALL BURRS		SCALE	WT. SHEET 1 OF 1



NOTES:

1. T1, STANCOR P-6425
GRN. AND YEL LEADS CUT OFF
CLOSE TO CASE.

		REV.	AMR		ADVANCED METALS RESEARCH CORP. BURLINGTON MASS.	
		REMARKS	TOLERANCES (EXCEPT AS NOTED)		DWN.	TITLE
			DECIMAL $\pm .005$	DATE	P.M.	300V POWER SUPPLY
			FRACTION $\pm 1/64$	APR	DB	MATL.
			ANGULAR $\pm 1/4^\circ$	DATE	2-5-76	SEM-1000
		DATE	NEXT ASSY CS-6375-2285		SCALE	NO REQD
					X	
					REV.	MA
					-	675-1289B



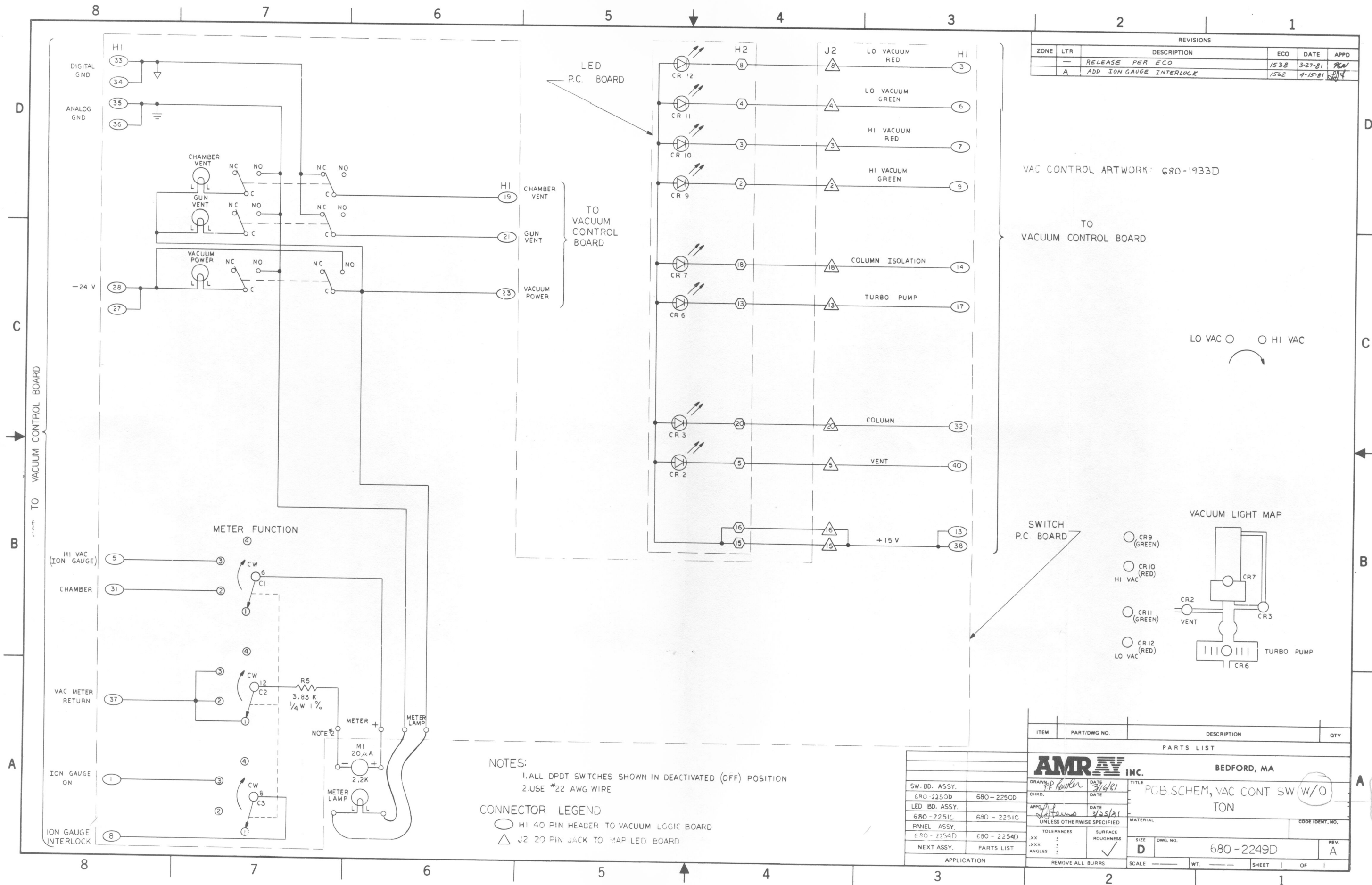
NOTES:

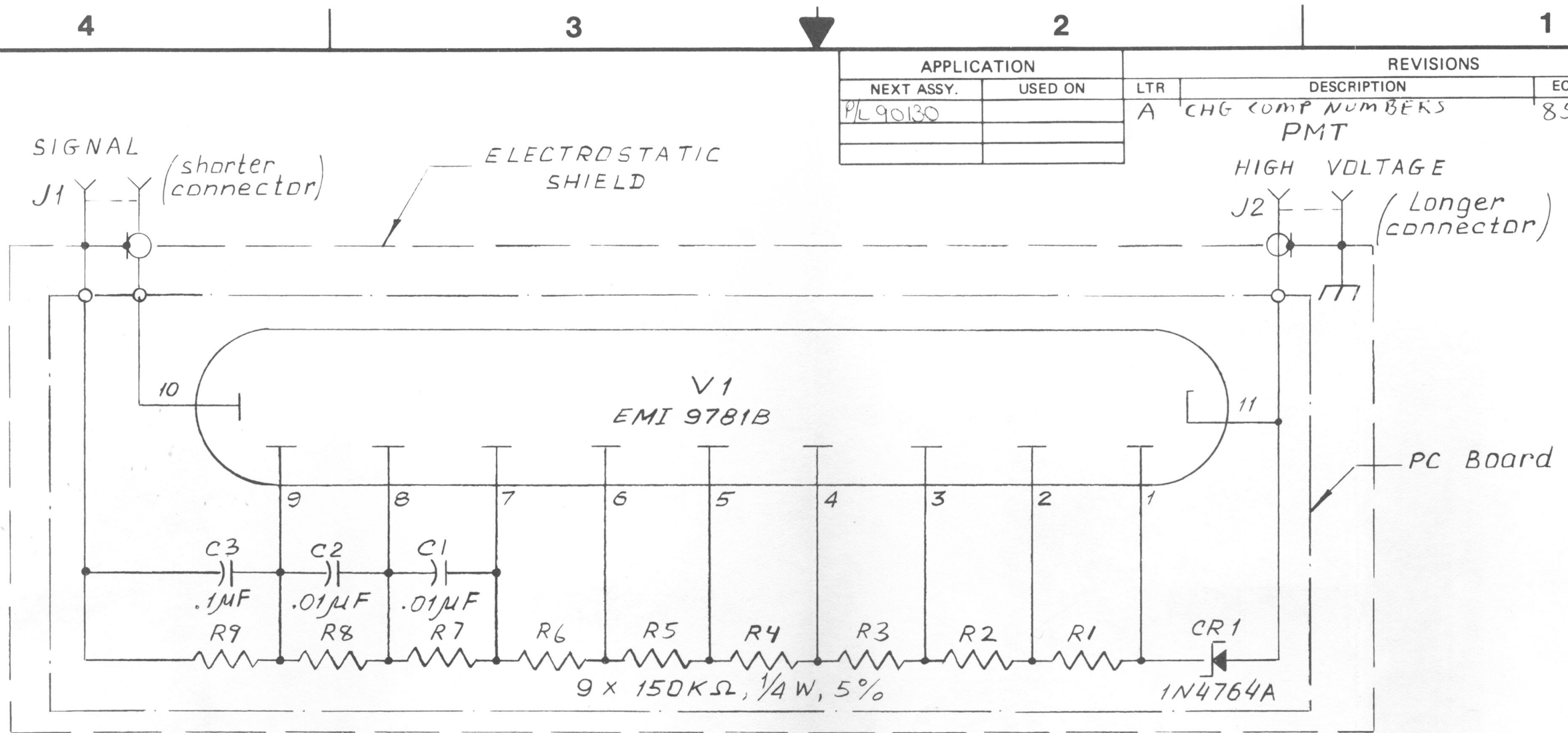
1. UNLESS OTHERWISE SPECIFIED;

A) ALL RESISTORS WILL BE IN OHMS, $\frac{1}{2}W$, 5%

B) ALL CAPACITORS WILL BE IN μF

REV.		AMR		ADVANCED METALS RESEARCH CORP. BURLINGTON MASS.	
A	REMARKS	TOLERANCES (EXCEPT AS NOTED)		TITLE	
		DECIMAL $\pm .005$		300V POWER SUPPLY CARD	
		FRACTION $\pm 1/64$		MATL.	
		ANGULAR $\pm 1/4^\circ$		SEM 1000	
	DATE	REMOVE ALL BURRS		REV.	
		NEXT ASSY CS-6375-2285		NO.	
		SCALE		A	
		NO REQD		675-1290B	

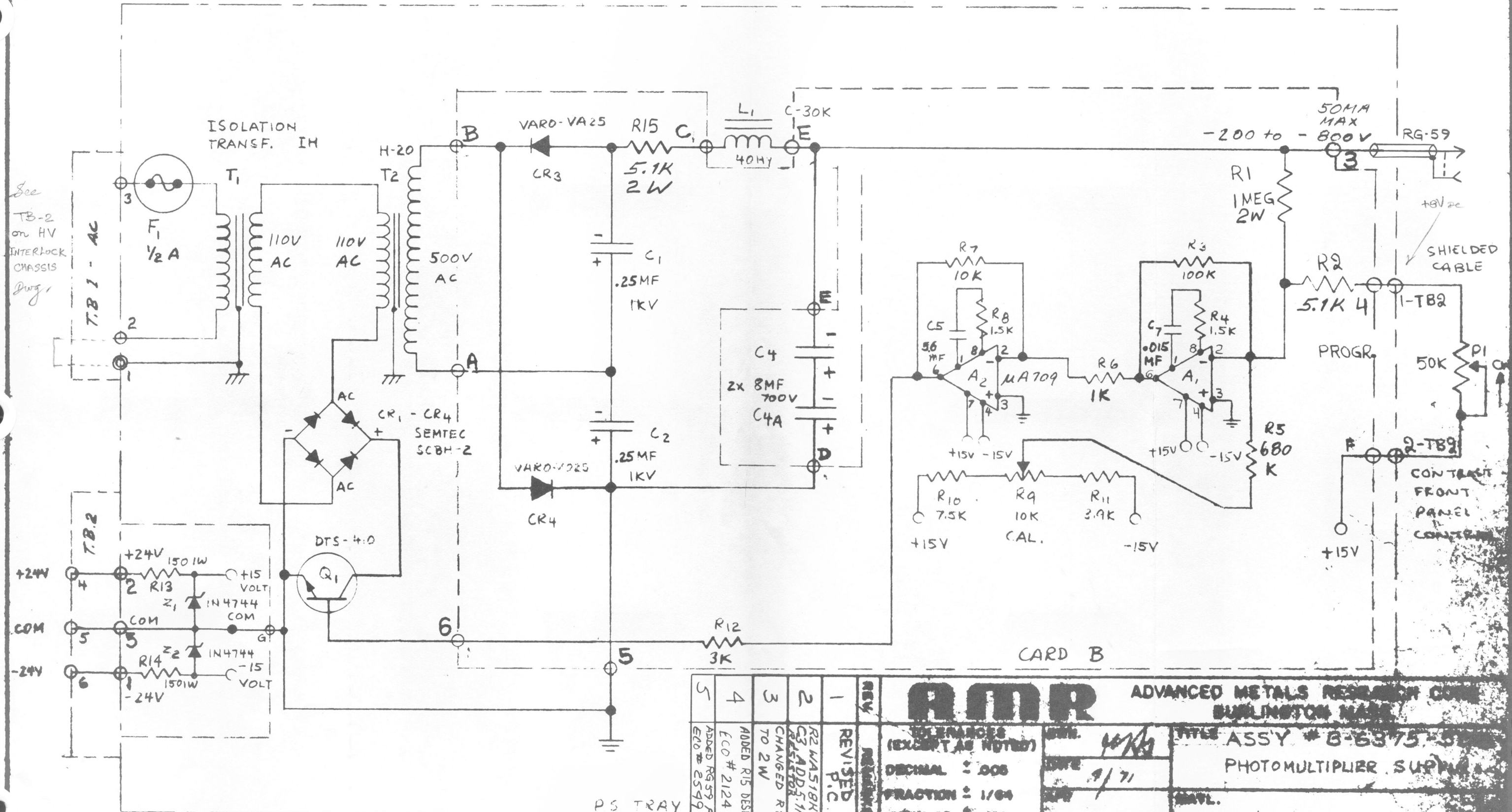




APPLICATION		REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE
PL 90130		A	CHG COMP NUMBERS	855	6-79
			PMT		

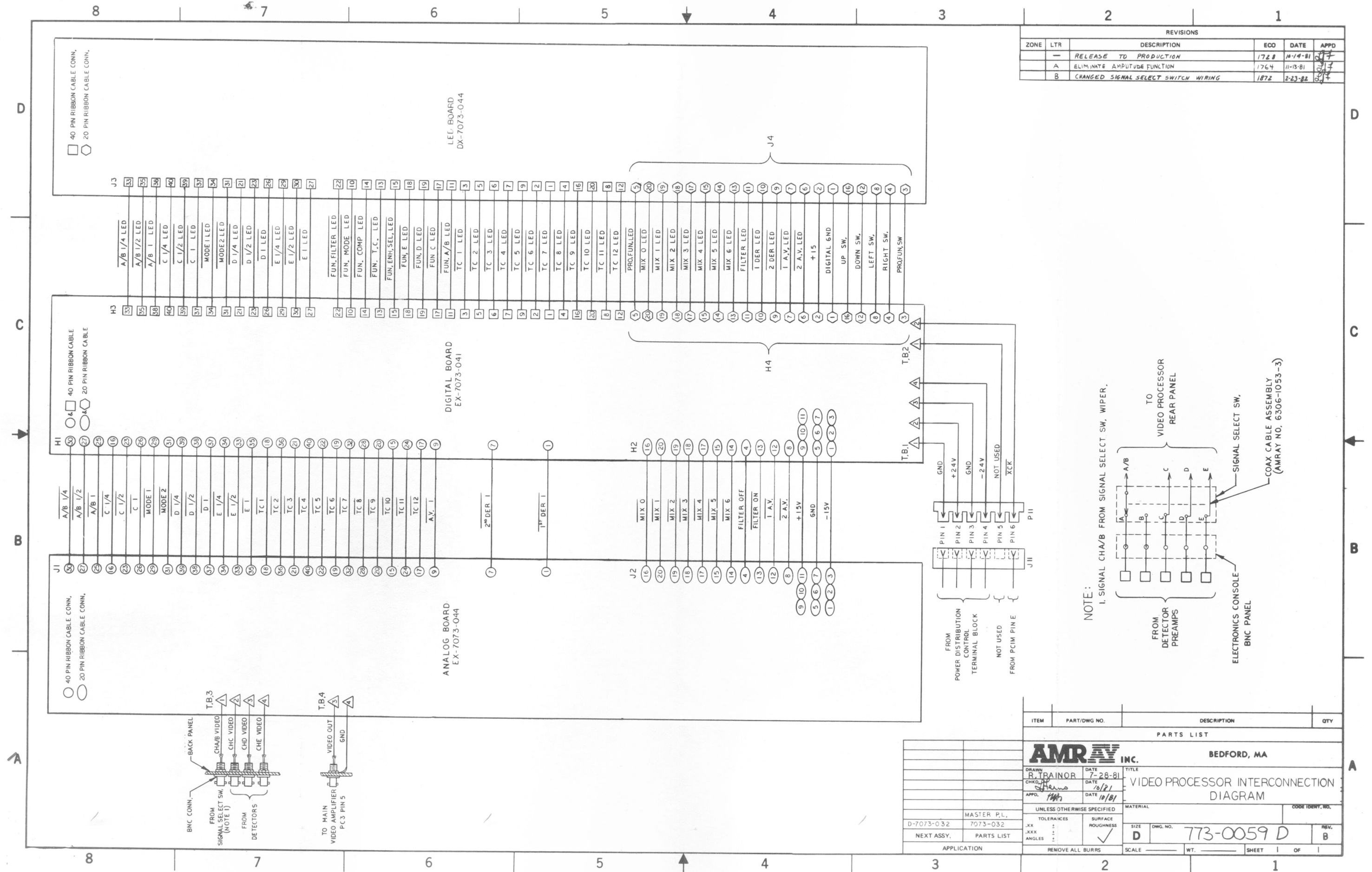
PL 90130					
ITEM	PART/DWG NO.	DESCRIPTION			QTY
PARTS LIST 90130/90159/90155					
AMR ADVANCED METALS RESEARCH CORP. BEDFORD, MASS.					
DWN. M. Goloshinsky		DATE 1-18-79		TITLE	
CHKD.		DATE		PHOTOMULTIPLIER ASSEMBLY	
APPD. D. BERRY		DATE 1-29-79		SCHEMATIC	
UNLESS OTHERWISE SPECIFIED				MATERIAL	
TOLERANCES		SURFACE ROUGHNESS		CODE IDENT. NO.	
.XX ±		✓		SIZE B	
.XXX ±				DWG. NO. 630-1805B	
ANGLES ±				REV. A	
REMOVE ALL BURRS		SCALE		WT. SHEET OF	

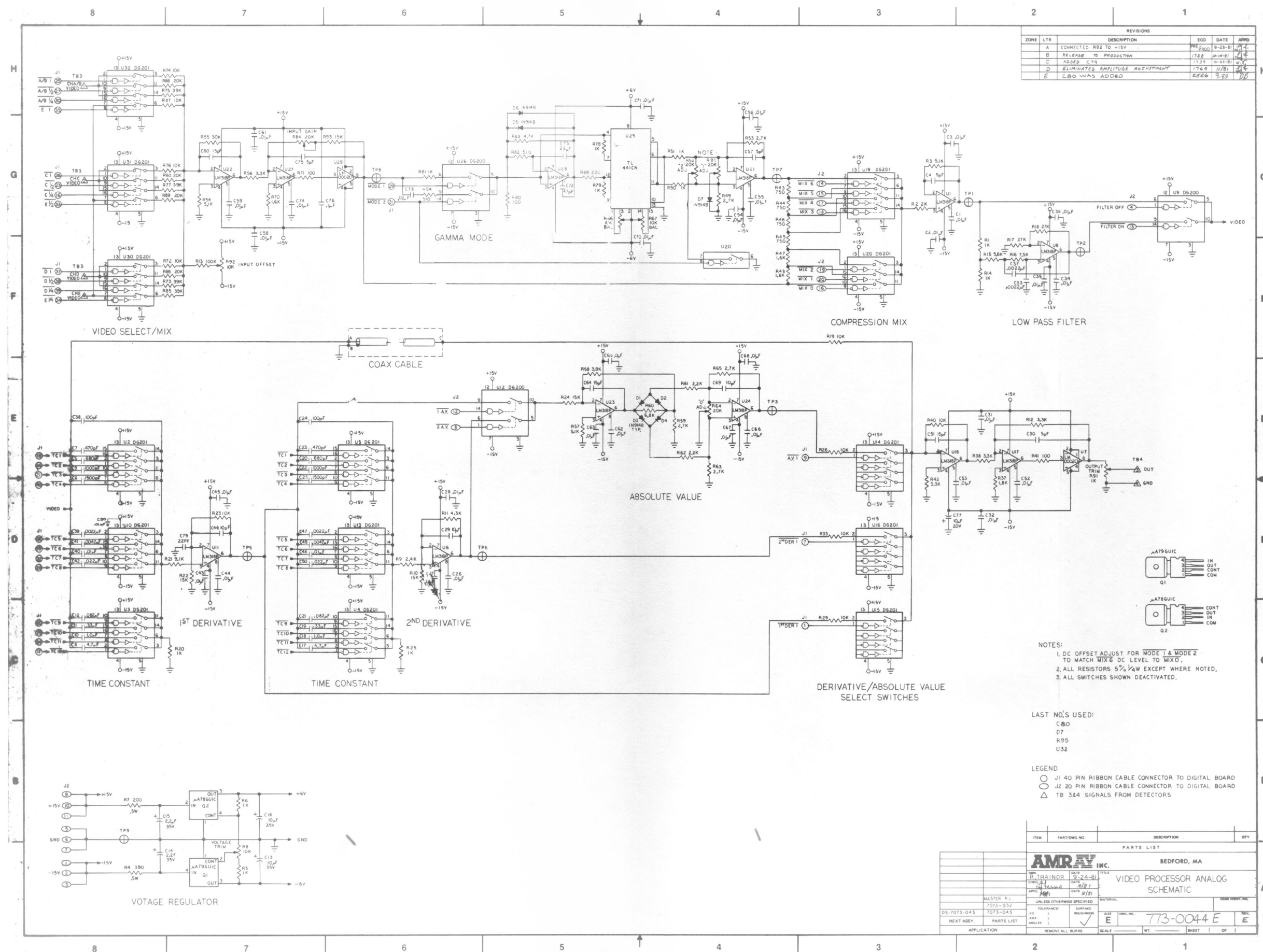
See
TB-2
on HV
INTERLOCK
CHASSIS
Dwg.

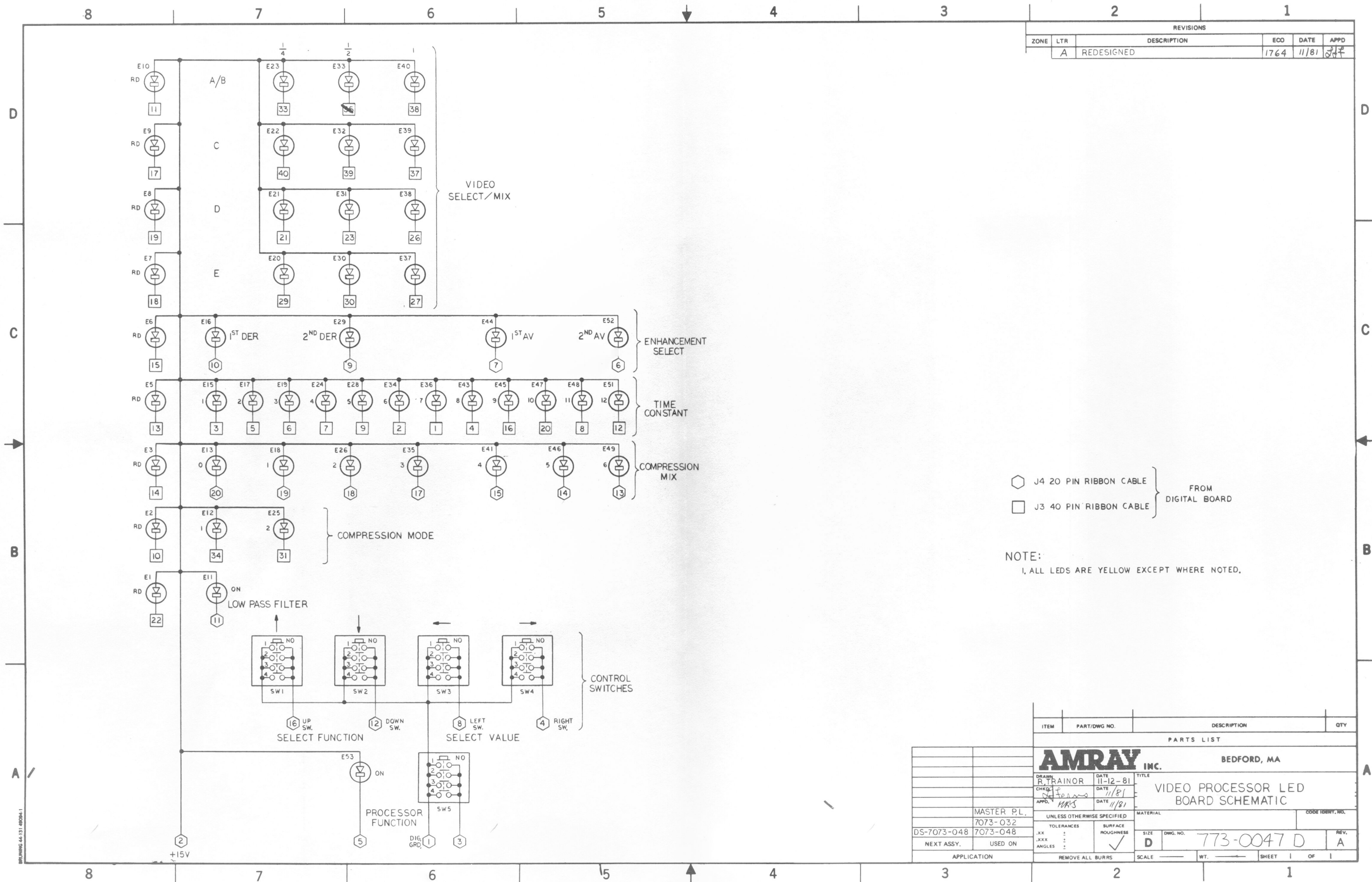


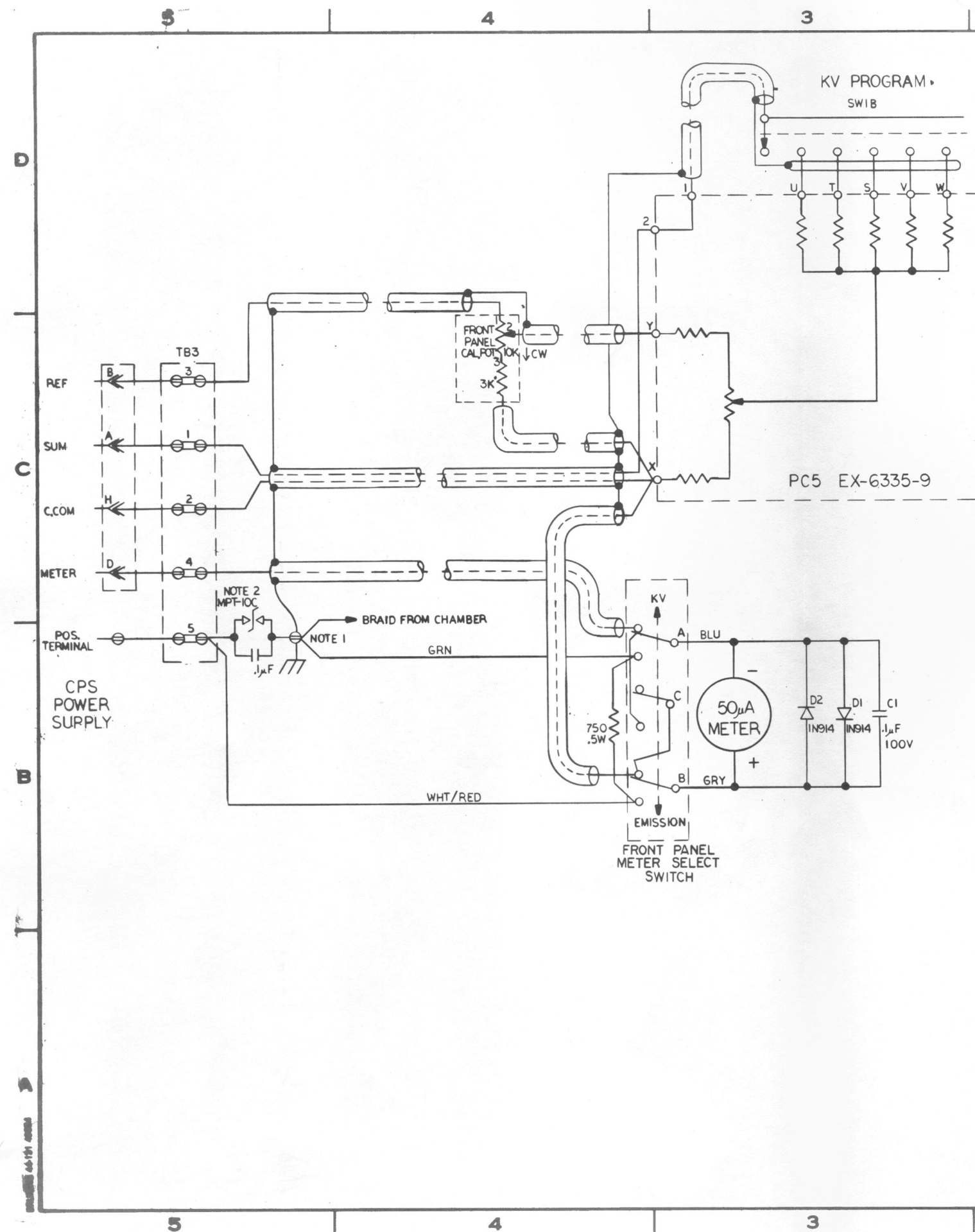
NOTE: ALL RESISTORS 5% 1/2WATT
UNLESS NOTED OTHERWISE

5	4	3	2	1	REV	AMR ADVANCED METALS RESEARCH CORP. BURLINGTON, MASS.		TITLE ASSY # B-6375-3 PHOTOMULTIPLIER SUPPLY	SEM. 1000 DATE 7/71 DATE 7/71	PMT PSU
5	4	3	2	1	REV	TOLERANCES (EXCEPT AS NOTED) DECIMAL : .005 FRACTION : 1/64 ANGULAR : 1/4° REMOVE ALL BURRS NEXT ASSY		DATE 7/71 DATE 7/71	SEM - 1000 675-00	PMT PSU
5	4	3	2	1	REV	R2 WAS 18K, DEL C3 ADD 5.1K 2W R15 FOR CHANGED R1 1/2W TO 2W ADDED R15 DESIGNATION ECO # 2124 ADDED RG59 PER ECO # 2549		DATE 7/71 DATE 7/71	SEM - 1000 675-00	PMT PSU







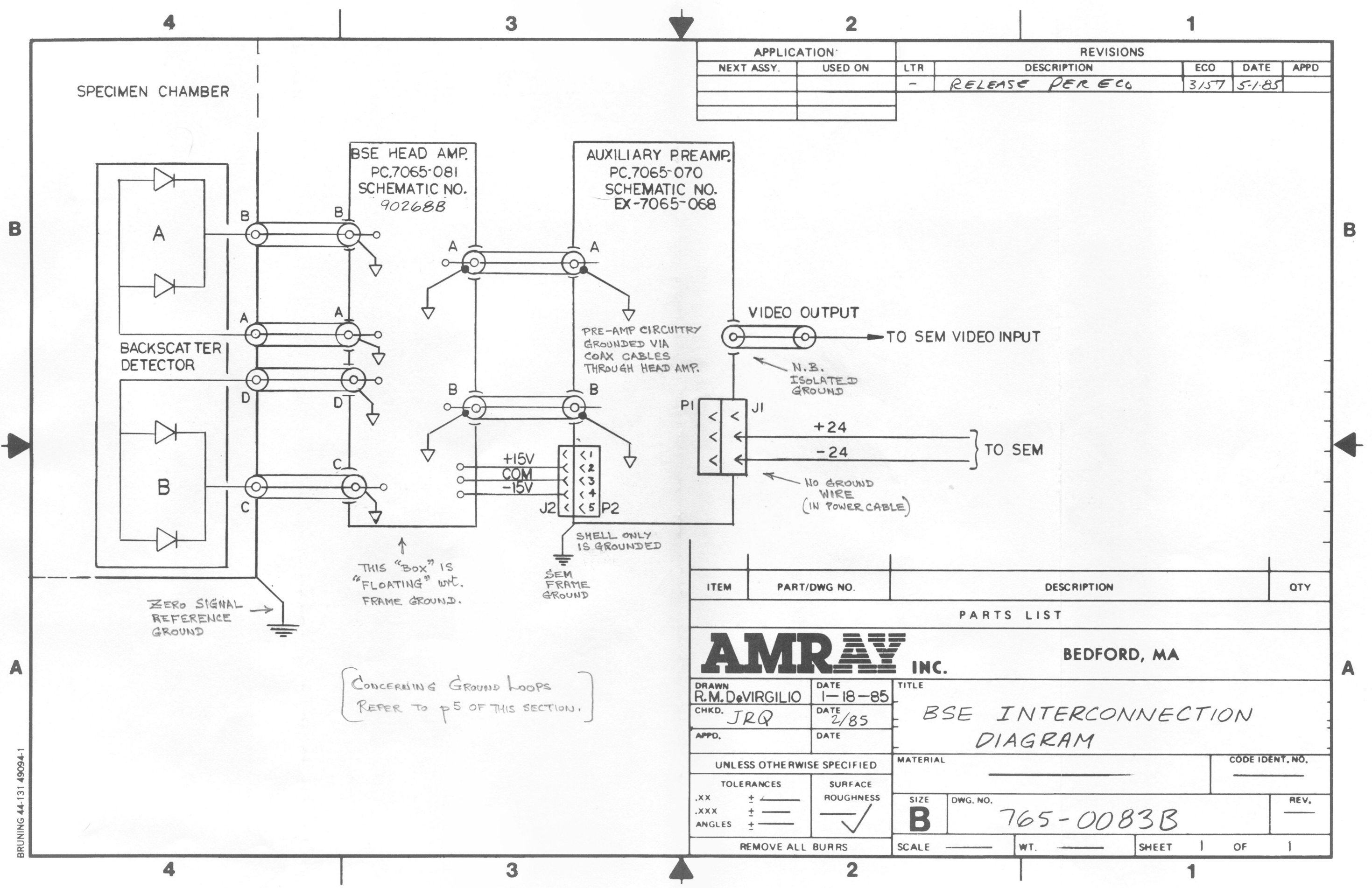


APPLICATION		REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE
	90154	A	REDESIGNED + REDRAWN	2071	6/82
		B	ADD C DECK ON METER SELECT SW	2108	7/6/82

- NOTES:
1. USE STAR WASHER UNDER SCREW FOR FRAME GND. (REMOVE PAINT FROM FRAME UNDER STAR WASHER.) LOCATE GROUNDING SCREW ON FRAME AS CLOSE AS POSSIBLE TO CPS SUPPLY.
 2. BIPOLAR CLAMP
 3. ALL RESISTORS MARKED ARE 1%.
 4. CUT WIRE TO PROPER LENGTH UPON INSTALLATION.

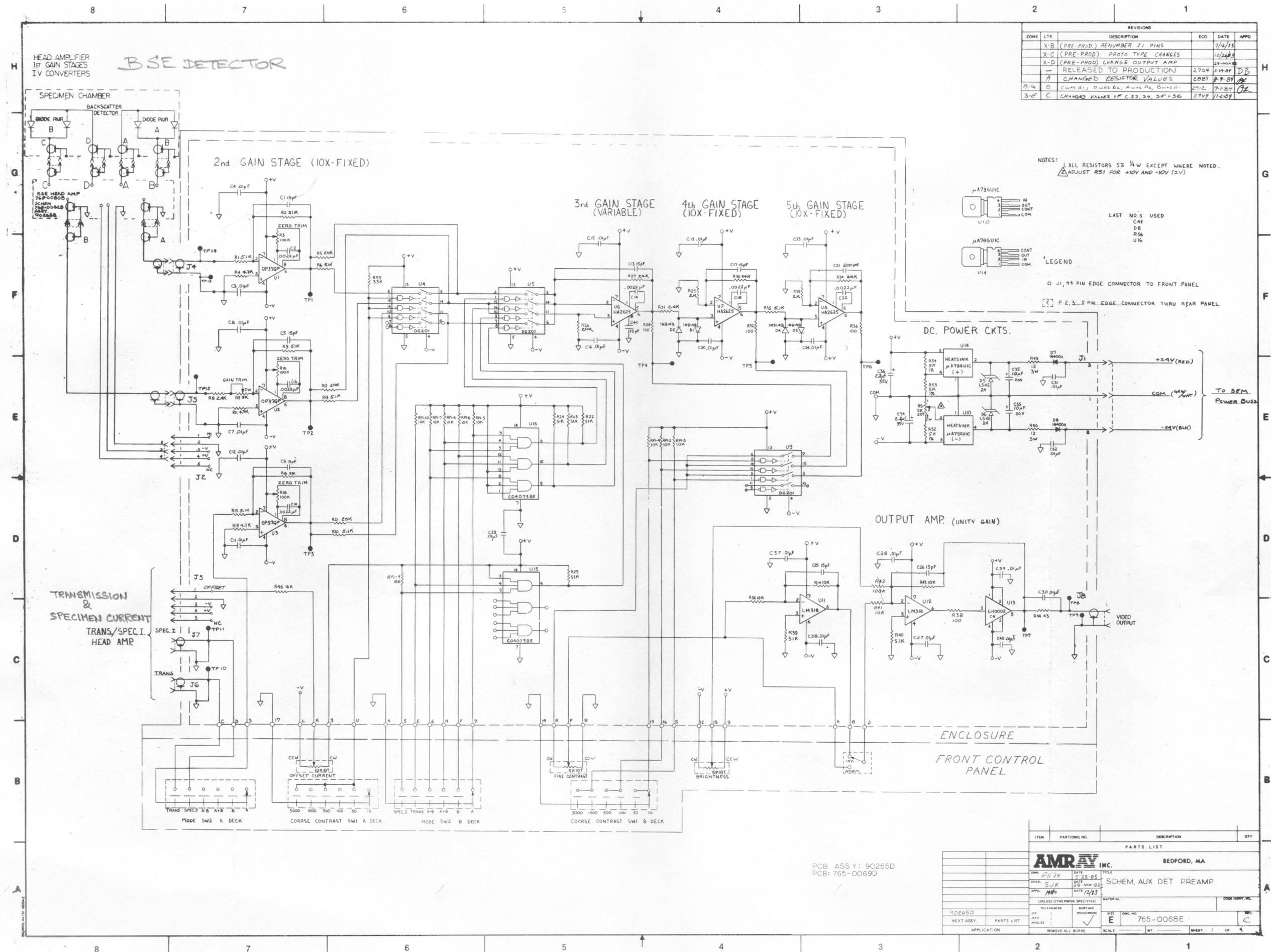
ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMR INC. BEDFORD, MA			
DRAWN R. TRINOR CHKD. APPD.	DATE 5-20-82 DATE 6/82 DATE 6/82	TITLE 1000 CONTINUOUS KV SCHEMATIC	
UNLESS OTHERWISE SPECIFIED		CODE IDENT. NO.	
TOLERANCES .XX ± .XXX ± ANGLES ±	SURFACE ROUGHNESS ✓	SIZE C	DWG. NO. 661-1980C
REMOVE ALL BURRS		SCALE	WT. SHEET OF

APPLICATION		REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE
		-	RELEASE PER ECO	3/5/7	5-1-85



ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMRAY INC. BEDFORD, MA			
DRAWN R.M. DeVIRGILIO CHKD. JRQ APPD. DATE 1-18-85 DATE 2/85		TITLE BSE INTERCONNECTION DIAGRAM	
UNLESS OTHERWISE SPECIFIED TOLERANCES .XX ± .XXX ± ANGLES ± SURFACE ROUGHNESS 		MATERIAL CODE IDENT. NO.	
REMOVE ALL BURRS		SIZE B DWG. NO. 765-0083B REV. 	
SCALE		SHEET 1 OF 1	

BRUNING 44-131 49094-1

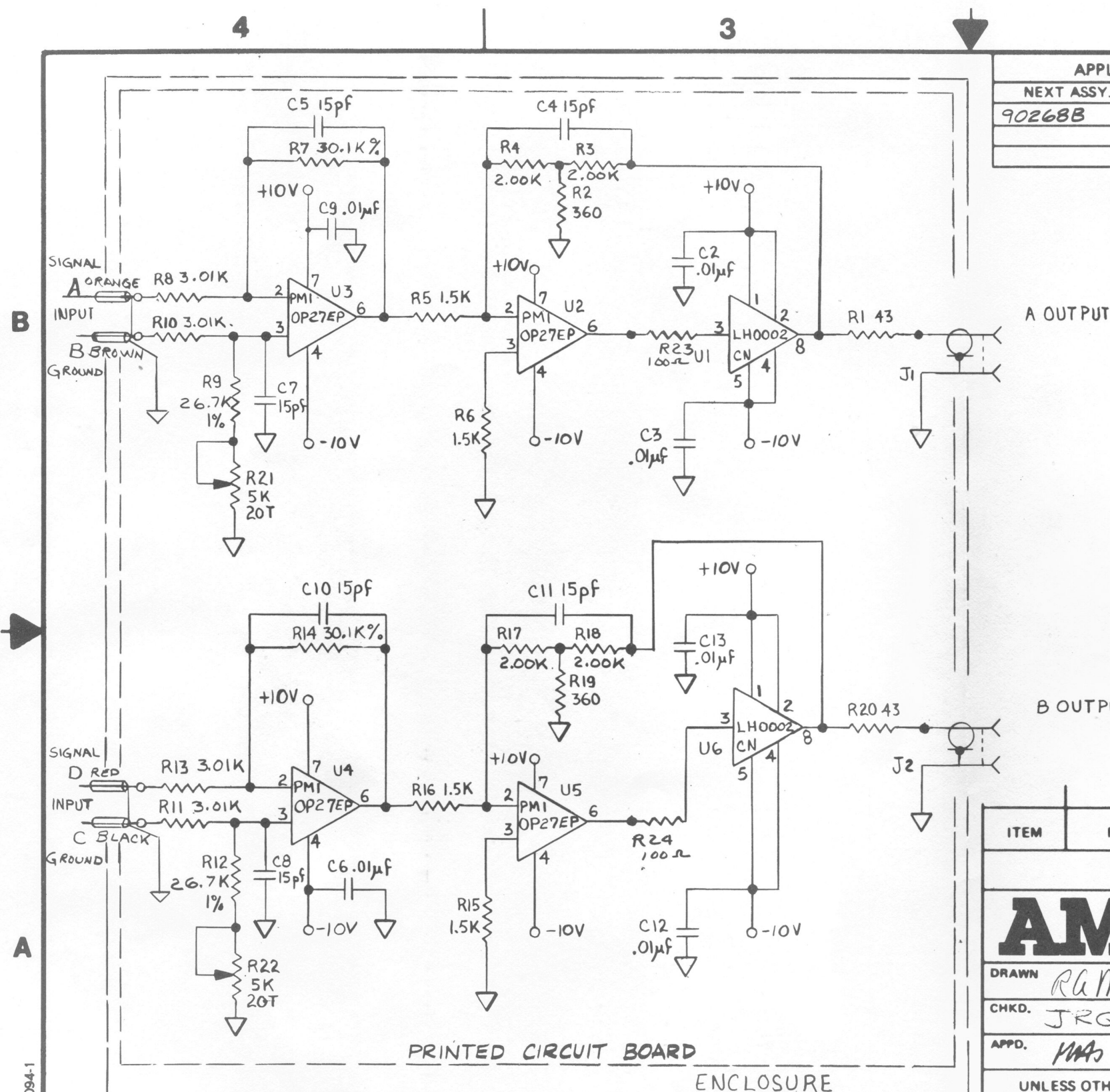


APPLICATION			REVISIONS			
NEXT ASSY.	USED ON	LTR	DESCRIPTION	ECO	DATE	APPD
90268B		-	RELEASE TO PRODUCTION	2704	2-23-84	DB
		B	ADDED R23+R24	2889	8-9-84	
		D	ADDED GROUND	3040	1-29-85	

LAST NO. USED
C13
R24
U6

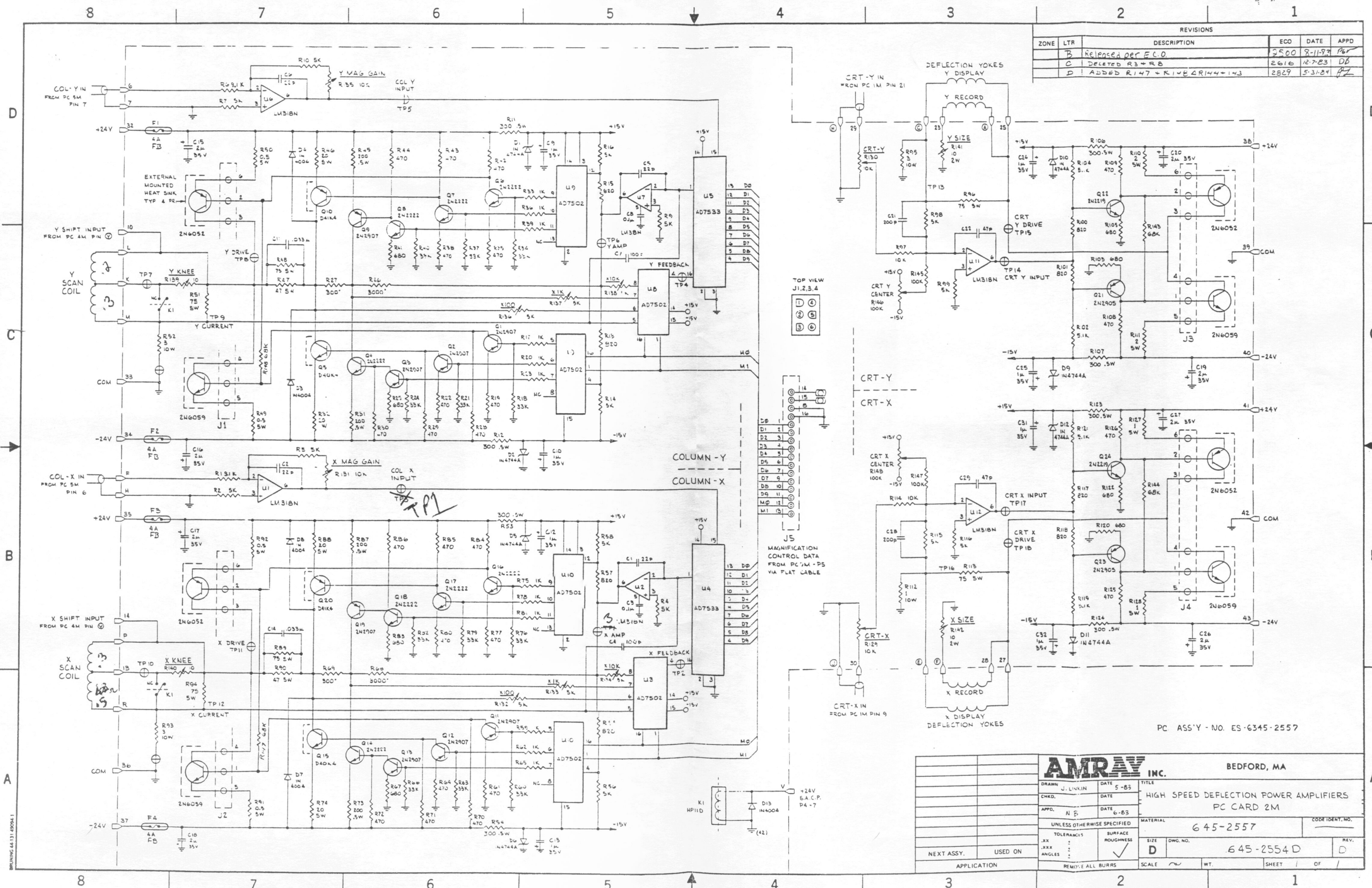
PCB: 765-0080B

ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST -			
AMRAY INC.		BEDFORD, MA	
DRAWN <i>RGM</i>	DATE 10-27-83	TITLE	
CHKD. <i>JRQ</i>	DATE 11-22-83	PCB SCHEM, BSE HEAD AMP.	
APPD. <i>MAS</i>	DATE 12/83		
UNLESS OTHERWISE SPECIFIED		MATERIAL	CODE IDENT. NO.
TOLERANCES .XX ± .XXX ± ANGLES ±	SURFACE ROUGHNESS ✓	SIZE B	DWG. NO. 90268B
REMOVE ALL BURRS		SCALE	WT.
		SHEET 3	OF 3



NOTES:

1. ALL RESISTORS 5%, 1/4 W EXCEPT WHERE NOTED.
2. OUTPUT CONNECTORS ARE ISOLATED BNC'S

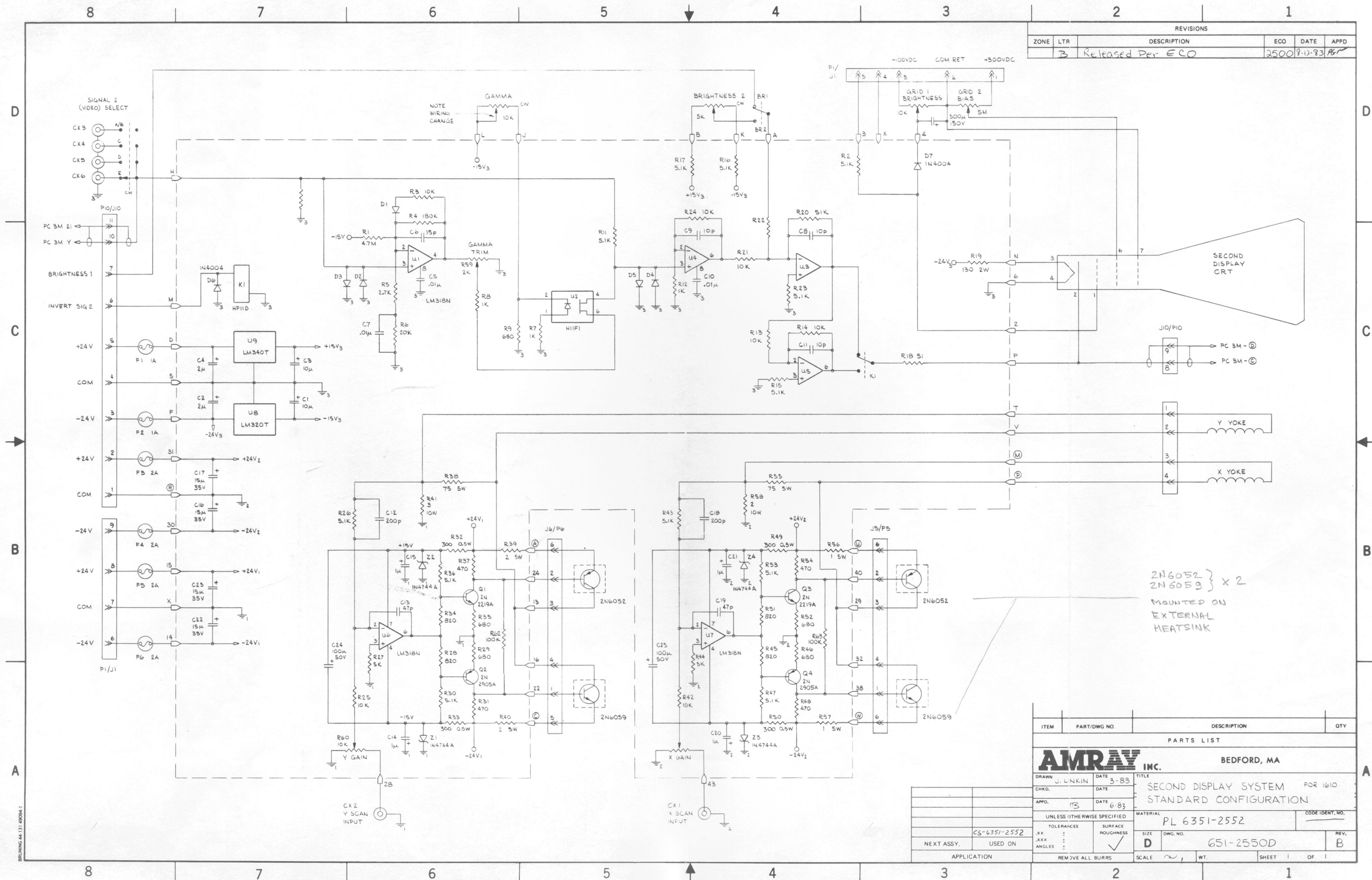


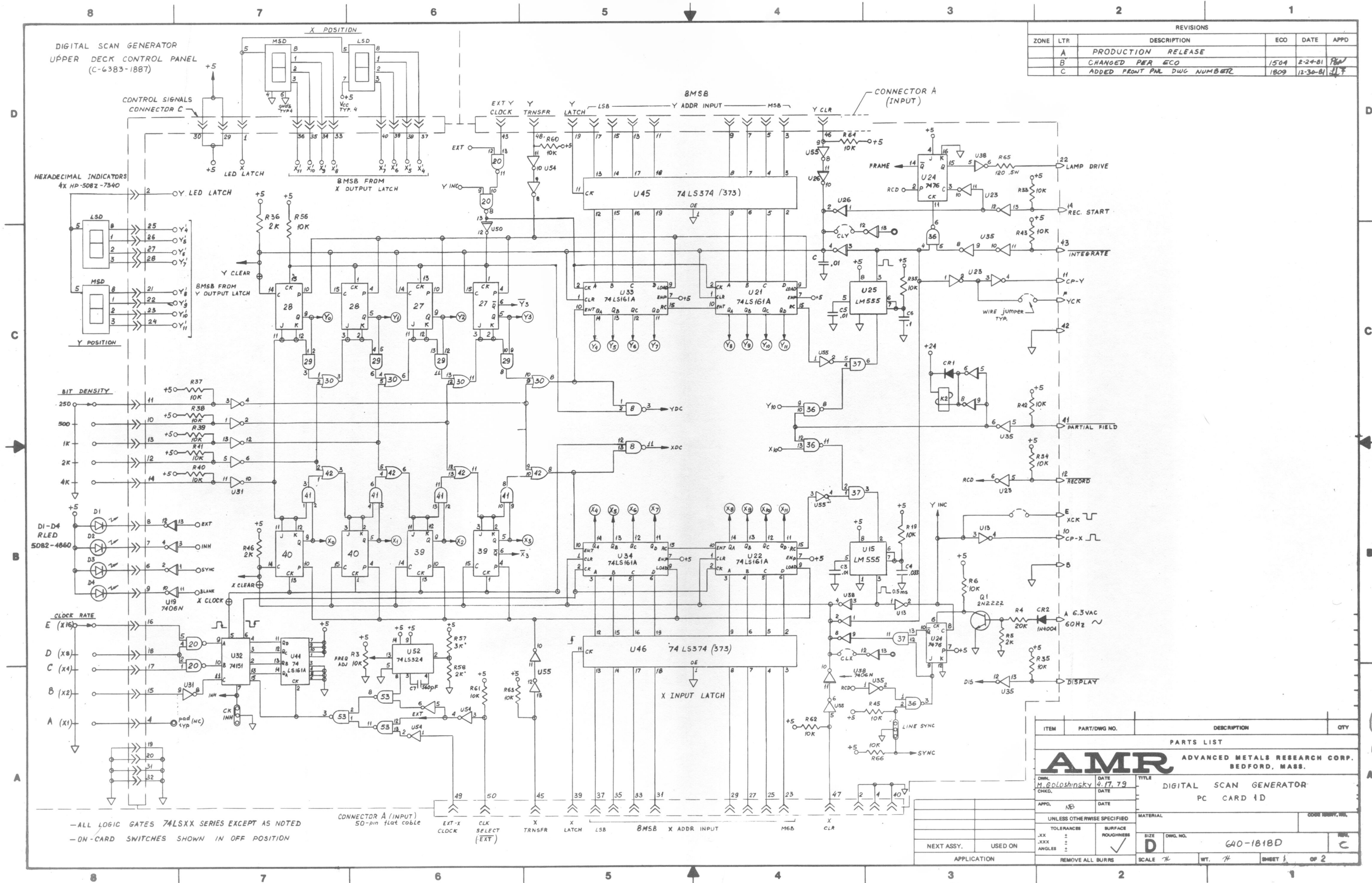
REVISIONS				
ZONE	LTR	DESCRIPTION	ECO	DATE
B		RELEASED PER E.C.O.	2500	8-11-83
C		DELETED R3 + R8	2616	12-7-83
D		ADDED R147 + R148 CR144 + 143	2829	5-31-84

DRAWN J. LUKIN		DATE 5-83	TITLE	
CHKD.		DATE	HIGH SPEED DEFLECTION POWER AMPLIFIERS	
APPD. N. S.		DATE 6-83	PC CARD 2M	
UNLESS OTHERWISE SPECIFIED		MATERIAL		
TOLERANCES		645-2557		
SURFACE ROUGHNESS		CODE IDENT. NO.		
NEXT ASSY.		SIZE		
USED ON		D		
APPLICATION		SCALE		
REMOVED ALL BURRS		SHEET 1 OF 1		

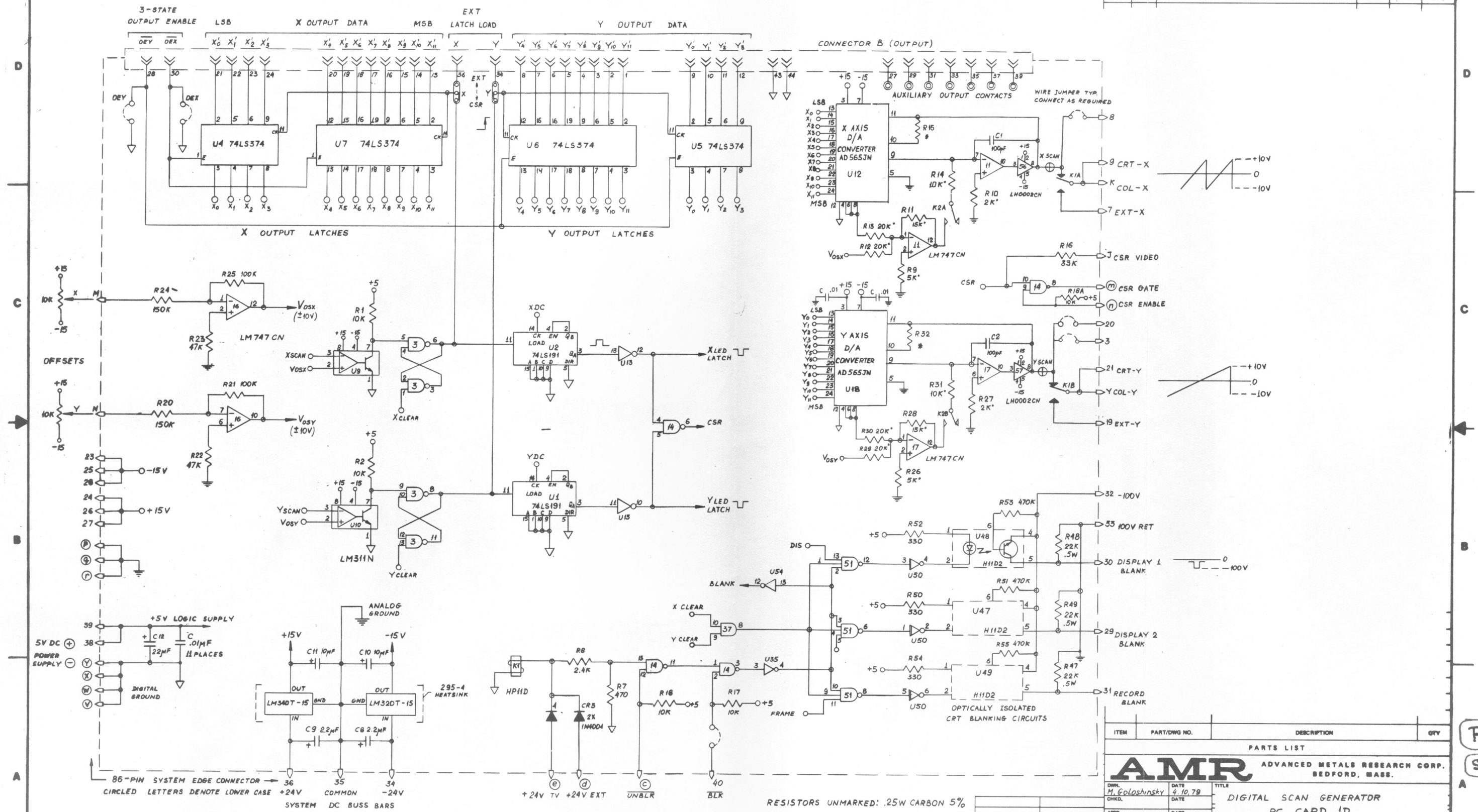
AMRAY INC. BEDFORD, MA

PC ASS'Y - NO. ES-6345-2557





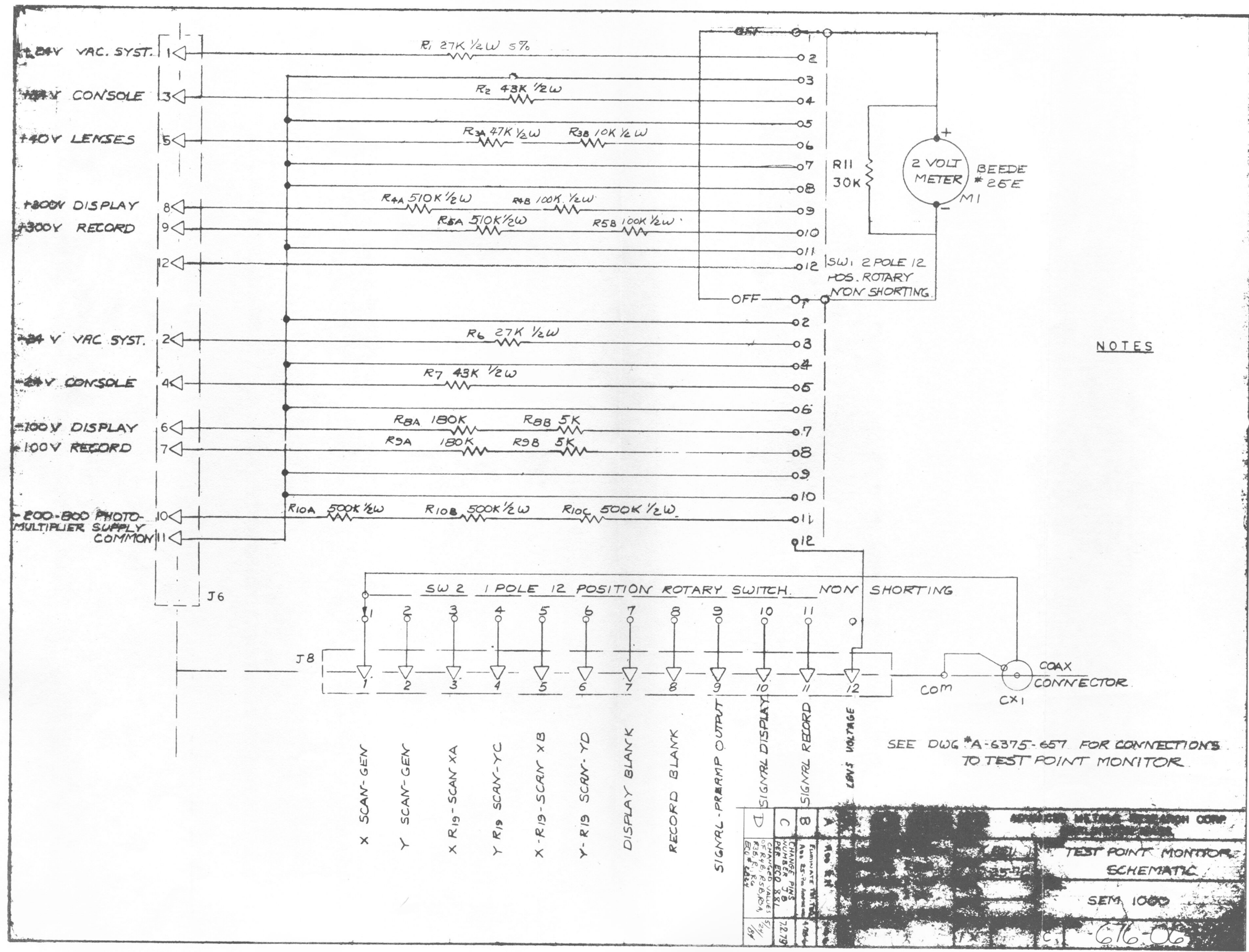
REVISIONS				
ZONE	LTR	DESCRIPTION	ECO	DATE



RESISTORS UNMARKED: .25W CARBON 5%
 RESISTORS MARKED *: .25W CERMET 1%
 RESISTORS MARKED #: OPTIONAL, FOR
 REDUCTION OF OUTPUT AMPLITUDE
 RELAYS SHOWN DEACTIVATED

ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST			
AMR ADVANCED METALS RESEARCH CORP. BEDFORD, MASS.			
DWG. M. Goloshinsky	DATE 4.10.79	TITLE	
CHKD.	DATE	DIGITAL SCAN GENERATOR	
APPD. MB	DATE	PC CARD ID	
UNLESS OTHERWISE SPECIFIED		MATERIAL	
TOLERANCES	SURFACE	SIZE	DWG. NO.
XXX	ROUGHNESS	D	640-1818D
ANGLES		SCALE	WT.
APPLICATION		REMOVE ALL BURRS	
NEXT ASSY. USED ON		SHEET 2 OF 2	

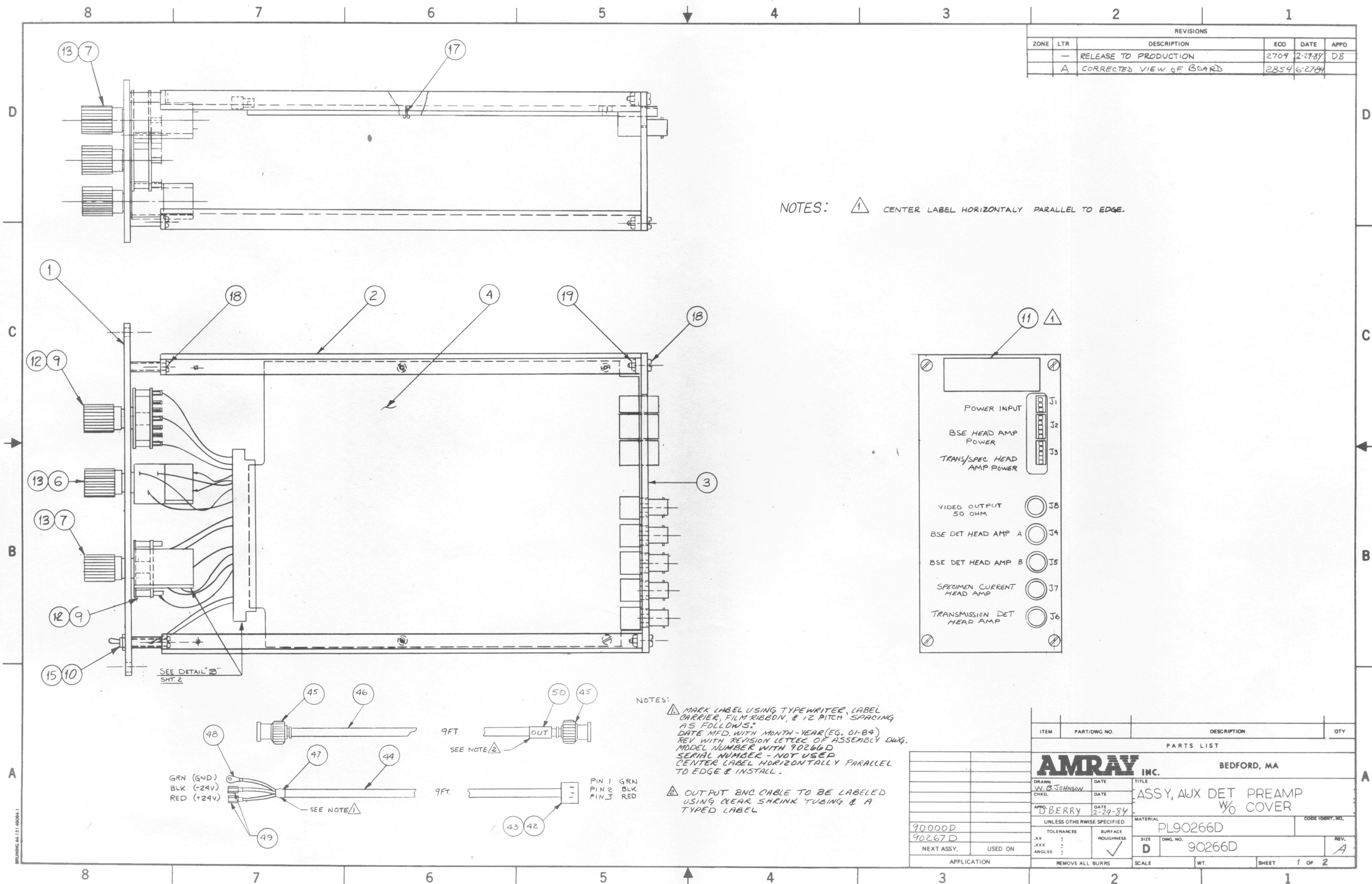
PC-ID
 SHEET 2



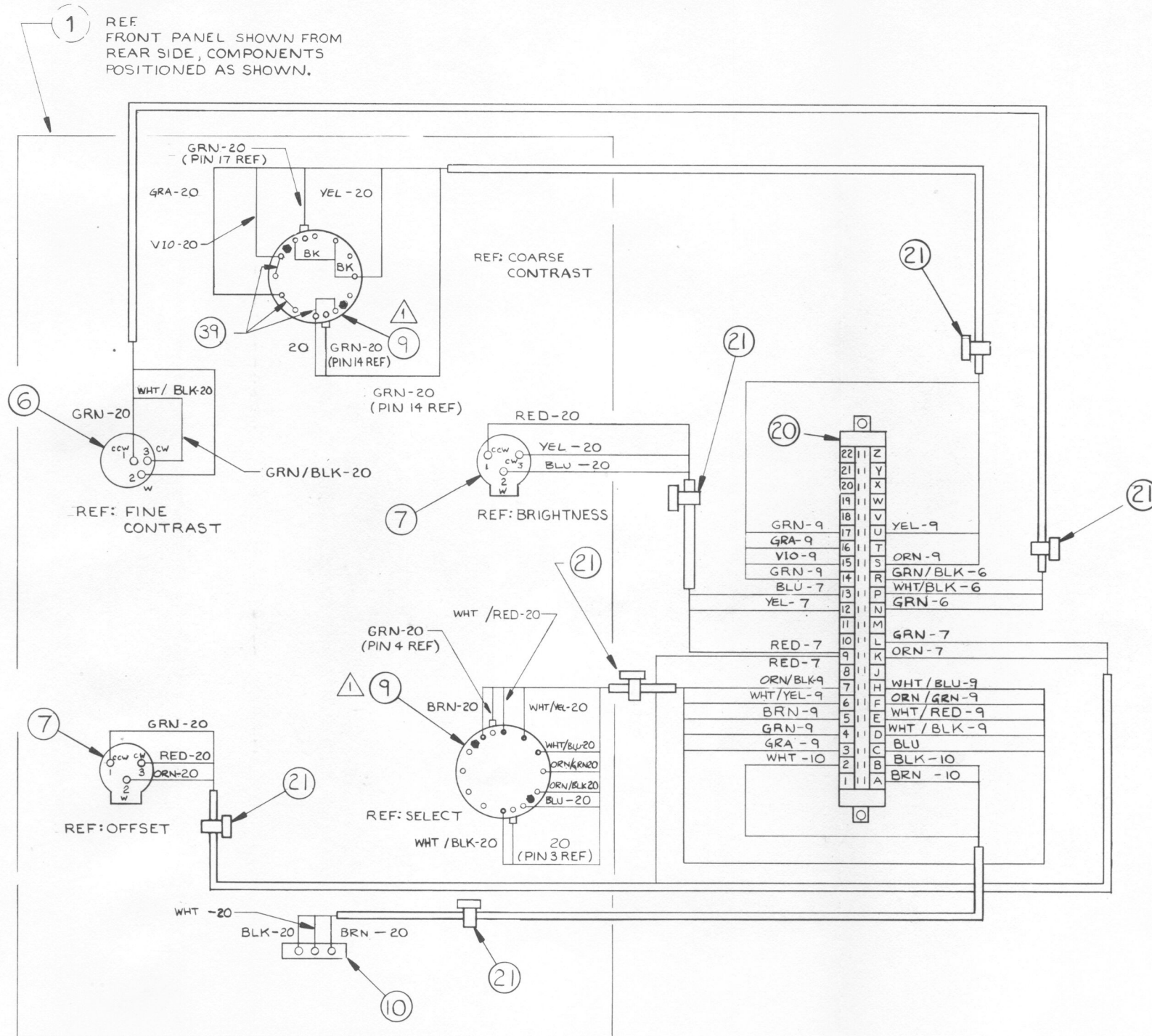
NOTES

REVISIONS			
REV	DATE	BY	DESCRIPTION
1	10-1-64	W. J. H.	INITIAL DESIGN
2	10-1-64	W. J. H.	REVISIONS
3	10-1-64	W. J. H.	REVISIONS
4	10-1-64	W. J. H.	REVISIONS
5	10-1-64	W. J. H.	REVISIONS
6	10-1-64	W. J. H.	REVISIONS
7	10-1-64	W. J. H.	REVISIONS
8	10-1-64	W. J. H.	REVISIONS
9	10-1-64	W. J. H.	REVISIONS
10	10-1-64	W. J. H.	REVISIONS
11	10-1-64	W. J. H.	REVISIONS
12	10-1-64	W. J. H.	REVISIONS
13	10-1-64	W. J. H.	REVISIONS
14	10-1-64	W. J. H.	REVISIONS
15	10-1-64	W. J. H.	REVISIONS
16	10-1-64	W. J. H.	REVISIONS
17	10-1-64	W. J. H.	REVISIONS
18	10-1-64	W. J. H.	REVISIONS
19	10-1-64	W. J. H.	REVISIONS
20	10-1-64	W. J. H.	REVISIONS
21	10-1-64	W. J. H.	REVISIONS
22	10-1-64	W. J. H.	REVISIONS
23	10-1-64	W. J. H.	REVISIONS
24	10-1-64	W. J. H.	REVISIONS
25	10-1-64	W. J. H.	REVISIONS
26	10-1-64	W. J. H.	REVISIONS
27	10-1-64	W. J. H.	REVISIONS
28	10-1-64	W. J. H.	REVISIONS
29	10-1-64	W. J. H.	REVISIONS
30	10-1-64	W. J. H.	REVISIONS
31	10-1-64	W. J. H.	REVISIONS
32	10-1-64	W. J. H.	REVISIONS
33	10-1-64	W. J. H.	REVISIONS
34	10-1-64	W. J. H.	REVISIONS
35	10-1-64	W. J. H.	REVISIONS
36	10-1-64	W. J. H.	REVISIONS
37	10-1-64	W. J. H.	REVISIONS
38	10-1-64	W. J. H.	REVISIONS
39	10-1-64	W. J. H.	REVISIONS
40	10-1-64	W. J. H.	REVISIONS
41	10-1-64	W. J. H.	REVISIONS
42	10-1-64	W. J. H.	REVISIONS
43	10-1-64	W. J. H.	REVISIONS
44	10-1-64	W. J. H.	REVISIONS
45	10-1-64	W. J. H.	REVISIONS
46	10-1-64	W. J. H.	REVISIONS
47	10-1-64	W. J. H.	REVISIONS
48	10-1-64	W. J. H.	REVISIONS
49	10-1-64	W. J. H.	REVISIONS
50	10-1-64	W. J. H.	REVISIONS
51	10-1-64	W. J. H.	REVISIONS
52	10-1-64	W. J. H.	REVISIONS
53	10-1-64	W. J. H.	REVISIONS
54	10-1-64	W. J. H.	REVISIONS
55	10-1-64	W. J. H.	REVISIONS
56	10-1-64	W. J. H.	REVISIONS
57	10-1-64	W. J. H.	REVISIONS
58	10-1-64	W. J. H.	REVISIONS
59	10-1-64	W. J. H.	REVISIONS
60	10-1-64	W. J. H.	REVISIONS
61	10-1-64	W. J. H.	REVISIONS
62	10-1-64	W. J. H.	REVISIONS
63	10-1-64	W. J. H.	REVISIONS
64	10-1-64	W. J. H.	REVISIONS
65	10-1-64	W. J. H.	REVISIONS
66	10-1-64	W. J. H.	REVISIONS
67	10-1-64	W. J. H.	REVISIONS
68	10-1-64	W. J. H.	REVISIONS
69	10-1-64	W. J. H.	REVISIONS
70	10-1-64	W. J. H.	REVISIONS
71	10-1-64	W. J. H.	REVISIONS
72	10-1-64	W. J. H.	REVISIONS
73	10-1-64	W. J. H.	REVISIONS
74	10-1-64	W. J. H.	REVISIONS
75	10-1-64	W. J. H.	REVISIONS
76	10-1-64	W. J. H.	REVISIONS
77	10-1-64	W. J. H.	REVISIONS
78	10-1-64	W. J. H.	REVISIONS
79	10-1-64	W. J. H.	REVISIONS
80	10-1-64	W. J. H.	REVISIONS
81	10-1-64	W. J. H.	REVISIONS
82	10-1-64	W. J. H.	REVISIONS
83	10-1-64	W. J. H.	REVISIONS
84	10-1-64	W. J. H.	REVISIONS
85	10-1-64	W. J. H.	REVISIONS
86	10-1-64	W. J. H.	REVISIONS
87	10-1-64	W. J. H.	REVISIONS
88	10-1-64	W. J. H.	REVISIONS
89	10-1-64	W. J. H.	REVISIONS
90	10-1-64	W. J. H.	REVISIONS
91	10-1-64	W. J. H.	REVISIONS
92	10-1-64	W. J. H.	REVISIONS
93	10-1-64	W. J. H.	REVISIONS
94	10-1-64	W. J. H.	REVISIONS
95	10-1-64	W. J. H.	REVISIONS
96	10-1-64	W. J. H.	REVISIONS
97	10-1-64	W. J. H.	REVISIONS
98	10-1-64	W. J. H.	REVISIONS
99	10-1-64	W. J. H.	REVISIONS
100	10-1-64	W. J. H.	REVISIONS

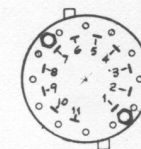
TEST POINT MONITOR
 SCHEMATIC
 SEM 1000
 676-06



REVISIONS					
ZONE	LTR	DESCRIPTION	ECO	DATE	APPD
	—	RELEASE TO PRODUCTION	2709	2-28-84	DB



WIRE COLOR REF. DESIGNATION	
BLACK	BLK
BROWN	BRN
RED	RED
ORANGE	ORN
YELLOW	YEL
GREEN	GRN
BLUE	BLU
VIOLET	VIO
GRAY	GRA
WHITE	WHT



FOR BOTH ROTARY SWITCHES KNOCK-OUT STOPS 1 THRU 4. INSTALL KNOBS WITH POINTERS, WITH POINTERS OPPOSITE FULLY CCW MARK WITH SWITCH IN FULLY CCW POSITION. KNOBS SPACED OF FRONT PANEL BY $\frac{1}{16}$ ".

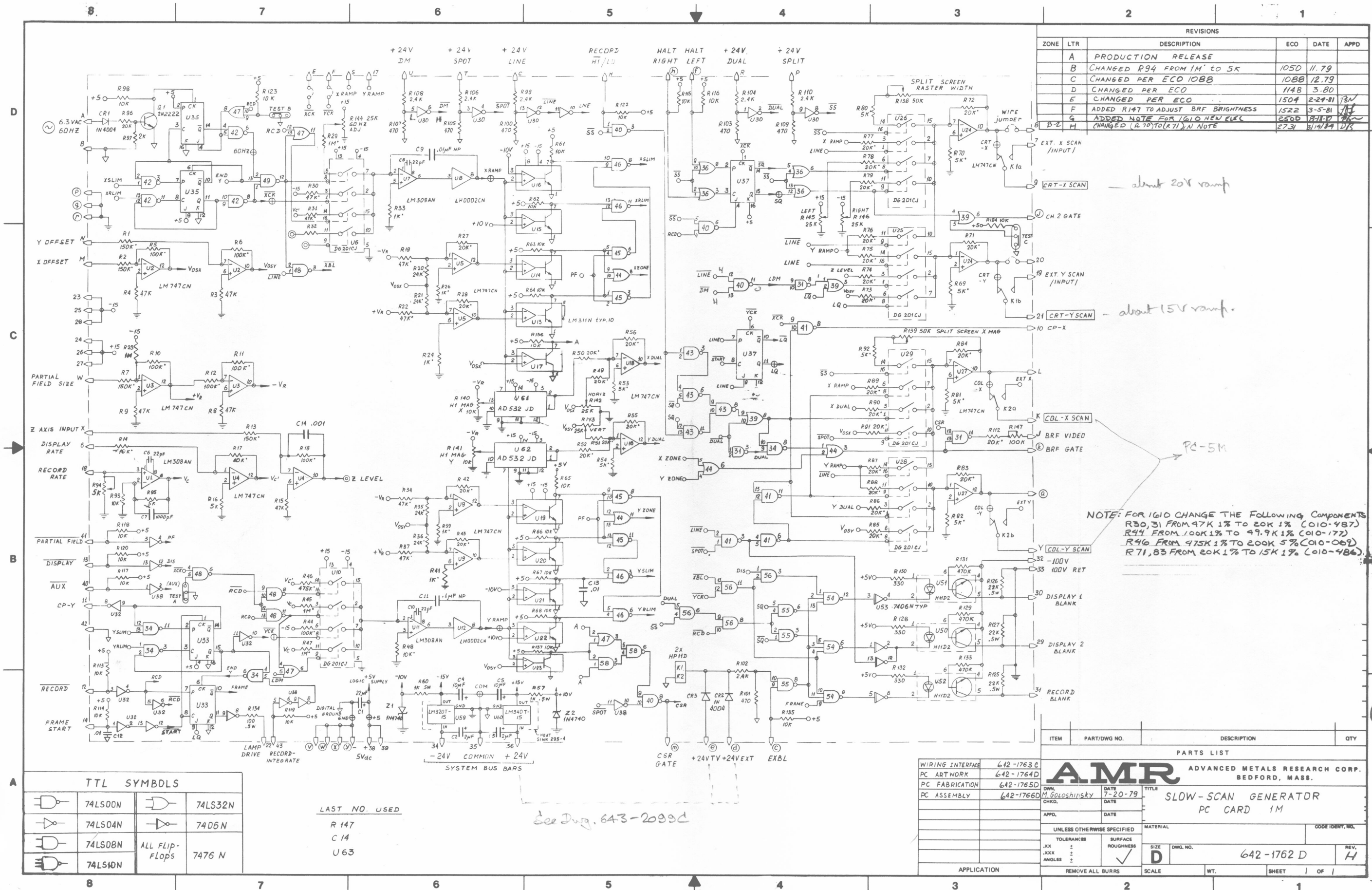
DETAIL "C"
ROTARY SWITCH DETAIL

NOTES:

ITEM 9: THE FOLLOWING ITEMS 28,30 ARE TO BE SOLDERED ON THE UNDERSIDE OF THE PLATE (WIPER).

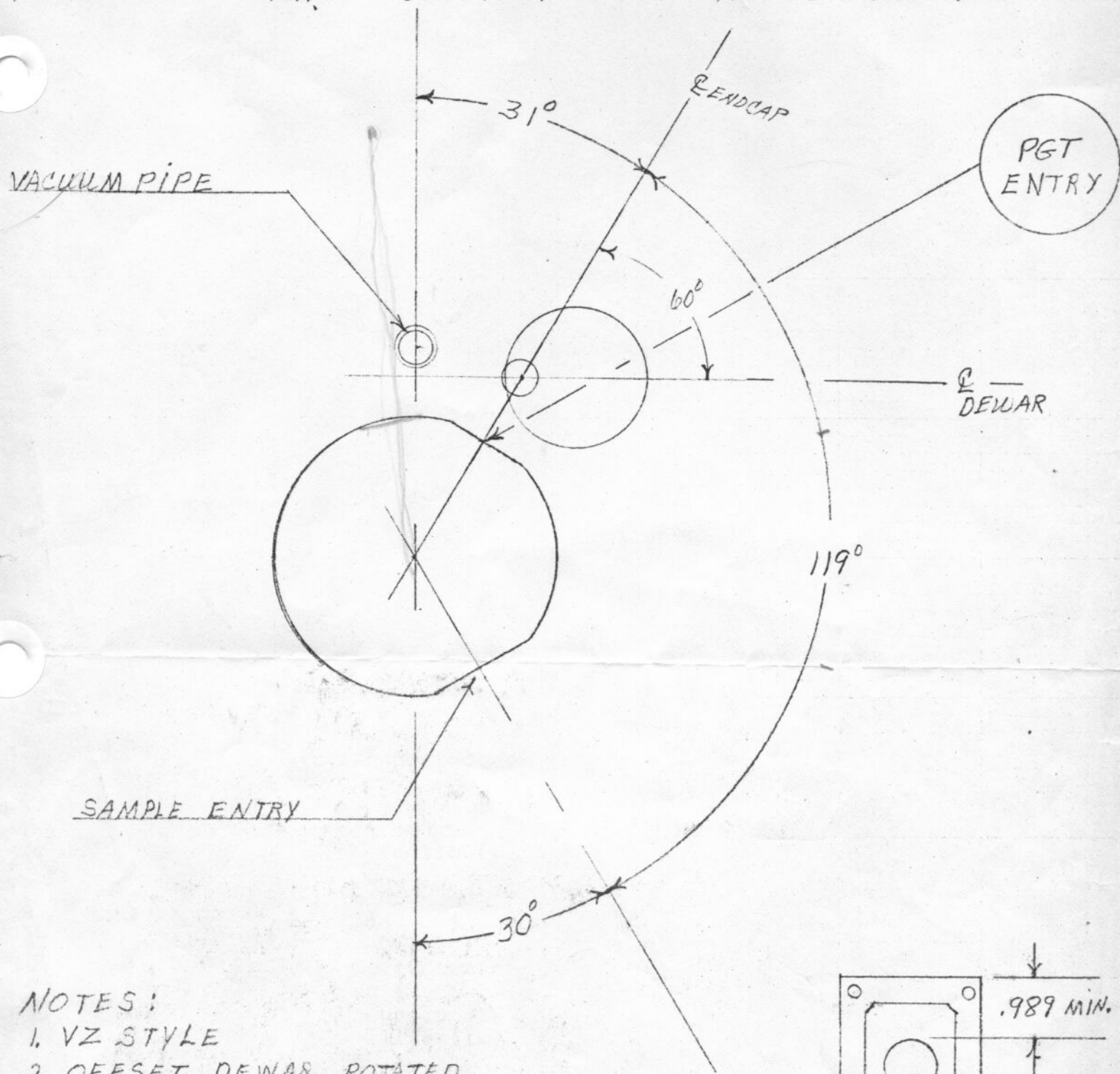
DETAIL "B"
WIRING DIAGRAM
SUB-ASSEMBLY

		ITEM	PART/DWG NO.	DESCRIPTION	QTY
PARTS LIST					
				BEDFORD, MA	
		DRAWN 	DATE 11/22/83	TITLE	
		CHKD. JRQ	DATE 12/83	ASSY, AUX DET PREAMP W/O COVER	
		APPD. 	DATE 12/83		
		UNLESS OTHERWISE SPECIFIED		MATERIAL _____	
		TOLERANCES	SURFACE	CODE IDENT. NO. _____	
		ROUGHNESS			
		.XX ±		REV. _____	
		.XXX ±		D _____ DWG. NO. 90266D	
		ANGLES ✓		A	
APPLICATION		REMOVE ALL BURRS		SCALE FULL	WT. _____
				SHEET 2	OF 2



PC-1M

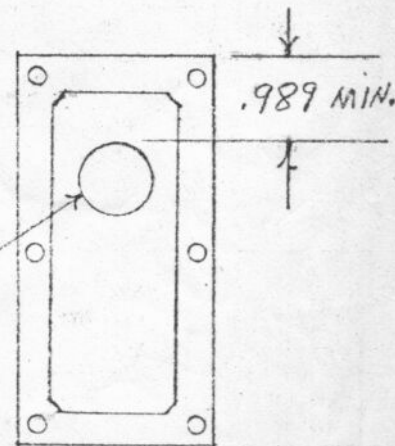
AMR-1000 LARGE UNIVERSAL PORT CHAMBER



NOTES:

1. VZ STYLE
2. OFFSET DEWAR ROTATED 60° CLOCKWISE.
3. INDICATORS L.H.
4. ENDCAP 9" LNG.

ENDCAP



PORT STYLE